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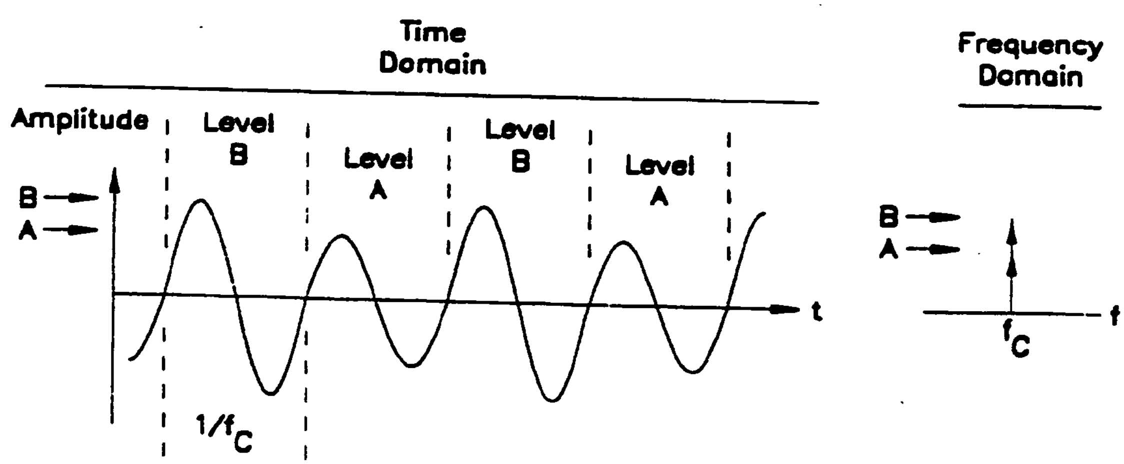

(57) Abstract

A communications method and apparatus for zero sideband amplitude modulation is described. Plural digital representations of sinewaves having different amplitudes but same periods are contained in a read-only memory. Selection between the digital representation of sinewaves having different amplitudes is based upon a digital modulation signal. Switching between the digital representations of sinewaves within the read-only memory is performed only at the zero crossing of the sinewave. The digital representations of the sinewaves are output to a digital to analog convertor to produce an RF amplitude modulated carrier signal with no sidebands. Since the switching of amplitude occurs at the zero crossing of the carrier, no upper sideband or lower sideband information results. The carrier frequency without sidebands is extremely narrow allowing multiple carriers containing high quality information to be closely spaced within the available communications spectrum. A many fold increase in the available use of the communications bandwidth is achieved.

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CARRIER MODULATION WITHOUT SIDEBANDS

FIELD OF INVENTION

The present invention relates to radio frequency modulation and transmission of information. In particular, the present invention relates to a method and apparatus for synthesizing all common forms RF modulation and further relates to a method and apparatus for amplitude modulation without creating any sideband information.

BACKGROUND OF INVENTION

Radio communication is accomplished by transmitting and receiving a radio frequency (RF) electromagnetic signal which has been modulated. Modulation is the process of varying some characteristic of a carrier wave in accordance with a signal to be conveyed. The RF carrier is an electromagnetic wave having at least one characteristic that can be varied from a known reference by modulation. The modulator is a circuit or device in which the RF carrier and the modulating signal come together to produce a modulated carrier, or one that processes the modulating signal and presents it to the circuit or device to be modulated. Demodulation is the process of deriving the original modulation signal from a modulated carrier wave. The carrier wave for radio frequency transmission is a signal which is typically at least twice the frequency of the modulating signal also known as the Nyquist frequency.

A wide variety of modulation techniques are known in the prior art for impressing a modulating signal onto a carrier. The modulating signal may be an analog type such as speech or music or the modulating signal may be of a digital type such as serial digital data, digitized analog signals and other digital data.

Whenever an RF carrier is modulated in the prior art, sidebands are produced. Sidebands are the frequency bands on both sides of an RF carrier resulting from the baseband signal (the range of frequencies occupied by the modulating signal before it modulates the carrier wave) varying some characteristic of the carrier. The prior art modulation process creates two sidebands: the upper sideband (USB) and the lower sideband (LSB). The width of each sideband is generally equal to the highest frequency component in the baseband signal. In some prior art modulation systems, the width of the sidebands may greatly exceed the highest baseband frequency component. The USB and LSB are mirror images of each other and carry identical information. Some modulation systems transmit only one sideband and partially or completely suppress the other in order to conserve bandwidth. The occupied bandwidth is the frequency between the lower and upper limits of the signal where the mean power drops off from the center to approximately 0.5 percent (minus 20 dB) of the total mean power (as described in the United States in the FCC rules governing communications). This bandwidth can be measured on a spectrum analyzer or can be calculated using the mathematics of information theory. Necessary bandwidth is that part of the occupied bandwidth sufficient to insure transmission of the information at the rate and with the quality required.

There are a plurality of major modulation systems used to transmit information by radio frequency. The categories of these modulation systems are determined based on how the main RF carrier is modulated. The major types are 1.) amplitude modulation (AM), 2.) angle modulation including frequency modulation (FM) and phase modulation (PM) and 3.) pulse modulation including pulse amplitude modulation (PAM), pulse width modulation (PWM), pulse duration modulation (PDM), pulse position

modulation (PPM), pulse phase modulation and others). By far, the most popular and the oldest form of carrier modulation is amplitude modulation.

Amplitude modulation (AM) covers a class of modulation systems in which the amplitude is the characteristic that is varied. This is described as varying the amplitude of the carrier from a zero power level to a peak power level. In the prior art, the amplitude modulation process produces sidebands on either side of the carrier frequency which are produced as a result of the process of heterodyning or non-linear mixing. In the prior art, when an RF carrier and a baseband modulation signal are combined there are three products that result in the RF frequency range: (1) the carrier frequency, (2) the lower sideband (LSB), and (3) the upper sideband (USB). Thus, for example, if a carrier of 10 megahertz (f_c) were modulated by a 1 kilohertz sinewave (f_m), the result would be as shown in Figure 1. The bandwidth of the modulated signal in this example would be 2 kilohertz, the difference between the lowest and highest frequencies ($f_{LSB} - f_{USB}$). In AM, the difference between the carrier and the farthest component of the sideband is determined by the highest frequency component contained in the baseband modulating signal.

Since there are a finite number of carrier frequencies available for modulation and transmission of information, the airwaves (earlier termed the ether) have been regulated by governments around the world to insure that this limited public resource is allocated evenly and fairly. The FCC in the United States regulates the assignment and use of RF carrier frequencies to insure non-conflicting use. Demand far outstrips supply in the number of modulating frequencies available for commercial exploitation, thus denying the use of the available airwaves to some.

There is, therefore, a need in the prior art to more efficiently use the airwaves to convey as much information as possible while consuming as little of the available spectrum as possible for each RF modulating signal. There is, therefore, a need in the prior art for modulation systems which use the least amount of bandwidth. There is also a need in the prior art to reduce or eliminate upper sidebands and lower sidebands from amplitude modulated signals such that the width of the carrier signal is all that is required to transmit an amplitude modulated signal.

There is also a need in the prior art to produce accurate and effective radio communication equipment to produce a plurality of carriers modulated by a variety of modulation types to make efficient use of the available communications spectrum. There is also a need in the prior art for universal radio transmitters and receivers based upon digital signal processing which are capable of modulating and demodulating carrier signals using a variety of modulation types.

These and other shortcomings of the prior art are cured by the present invention which has many additional advantages that will become apparent to those skilled in the art upon reading and understanding the present specification and drawings.

SUMMARY OF INVENTION

The present invention describes a method and apparatus for modulating radio frequencies using a variety of modulation techniques digitally derived from a communications processing system. In particular, the present invention describes a method and apparatus for producing an amplitude modulated carrier signal which has no sidebands. The amplitude of the carrier signal is changed only at the zero crossing of the carrier signal so that all transitions in amplitude occur without

producing sidebands. The amplitude modulated carrier may be modulated by a digital system, a digitized analog signal (such as audio, video, FAX, etc.) or other types of digital or digitized modulating signals (such ternary signals, serial digital data, parallel digital data, etc.). The result in the frequency domain is an RF carrier signal that does not vary in frequency but purely varies in amplitude only.

The present invention describes a method and apparatus of storing and retrieving digital representations of a sinewave from a read-only memory (ROM). The digital representations of sinewaves are stored in pages in memory such that each page contains the digital representation of a sinewave having the same period at different amplitudes. By reading out the digital representation of a sinewave at a high speed, converting it from a digital to an analog representation using a digital to analog converter, filtering or smoothing the digital representation into a purely analog one and transmitting by RF emission through an antenna, wire, fiber optic or microwave link, a perfect sinusoidal RF carrier signal is produced. By consecutively reading out the digital representation of the sinewave at a first amplitude followed by reading out the digital representation of the sinewave at a second amplitude, the second digital representation following the first digital representation only at the zero crossing point, a perfect amplitude modulated RF signal is produced having no sideband components. In the simplest implementation, by merely using a first amplitude and a second amplitude, a digitally modulated AM carrier signal is produced. By providing a large number of pages of digital representations of the sinewave at a plurality of amplitudes, a digitized analog signal (such as voice or music) can be used to digitally amplitude modulate the carrier.

By changing the rate at which the digital representation of the sinewave is read out of the read-only memory, the RF carrier frequency can be varied. By modulating the rate at which the digital representation of the sinewave is read out, frequency modulation of the RF carrier is produced. Frequency modulation, however, produces sidebands. By using a digital modulating signal to select which page of specific amplitude sinusoidal digital representations and by modulating the rate at which the digital representations are read out, a combination of amplitude and frequency modulation is produced.

The present invention also describes a method and apparatus for producing amplitude modulation, frequency modulation, amplitude and frequency modulation, and other modulation techniques using the same digital signal processing circuitry.

The present invention also describes a method and apparatus for producing an amplitude modulated carrier signal which has no sidebands by digitally modulating an analog carrier, by analog modulating a digitally produced carrier and by analog modulating an analog carrier. The amplitude of the carrier signal is changed only at the zero crossing of the carrier signal so that all transitions in amplitude occur without producing sidebands. The result in the frequency domain is an RF carrier signal that does not vary in frequency but purely varies in amplitude only.

BRIEF DESCRIPTION OF DRAWINGS

In the drawings, where like numerals refer to like components throughout the several views,

Figure 1 describes the prior art amplitude modulation in both the time domain and frequency domain.

Figure 2 shows an amplitude modulation signal in both the time domain and frequency domain in which no sidebands are produced from the present invention.

Figure 3 is a block diagram description of a zero sideband amplitude modulator of the present invention.

Figure 4 is a graph diagram representation of the bit memory map of a page of the read-only memory containing a digital representation of a sinewave at a first amplitude.

Figure 5 is a graph diagram representation of the bit memory map of a page of the read-only memory containing a digital representation of a sinewave at a second amplitude.

Figure 6 is a frequency domain representation of three closely spaced adjacent RF carriers amplitude modulated with zero sidebands.

Figure 7 is a block diagram of a combined amplitude modulator and frequency modulator circuit.

Figure 8 is a block diagram of a digital signal processing circuit for producing RF carriers using a plurality of modulation techniques including conventional modulation techniques and ZSB AM techniques.

Figure 9 is a block diagram of a communication system using the teachings of the present invention to transmit and receive ZSB AM through free space.

Figure 10 is a block diagram of a communication system using the teachings of the present invention to transmit and receive ZSB AM via satellite uplink and downlink using, for example, single carrier per channel.

Figure 11 is a block diagram of a communication system using the teachings of the present invention to transmit and receive ZSB AM over land based fiber optic links.

Figure 12 is a block diagram of a communication system using the teachings of the present invention to transmit and receive ZSB AM over terrestrial wire links.

Figure 13 is an example of a page memory map having m pages of digital representation of sinewaves, each page having a digital representation of a sinewave at a different amplitude.

Figures 14 through 18 are detailed electrical schematic diagrams of a circuit implementation of carrier modulation without sidebands.

Figure 19 is a block diagram of a communication system for accomplishing analog modulation of a digitally produced carrier to produce carrier modulation without sidebands.

Figure 20 is a block diagram of an apparatus for digital modulation of an analog RF carrier to produce carrier modulation without sidebands.

Figure 21 is a block diagram of an implementation of carrier modulation without sidebands by analog modulation of an analog RF signal source.

Figure 22 is a block diagram of an apparatus for digital modulation of an analog RF carrier to produce carrier modulation without sidebands of an alternate embodiment.

Figure 23 is a block diagram of an implementation of carrier modulation without sidebands by analog modulation of an analog RF signal source of an alternate embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings which form a part hereof and in which is shown by way of illustration a specific embodiment in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural, electrical or logical changes may be made without

departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

In Figure 1, a prior art unmodulated carrier is shown with both the time domain and the frequency domain. In the frequency domain, the unvarying frequency of the sinusoidal carrier f_c produces a single vector on the frequency spectrum. The modulating signal, also produces a single vector f_m on the frequency spectrum. The modulated carrier is a result of the mixing or heterodyning of the unmodulated carrier with the modulating signal resulting in a modulated carrier. The energy spectra shown in the frequency domain produces a single energy vector at the frequency of the carrier f_c along with upper sideband f_{USB} and lower sideband f_{LSB} vectors spaced apart from the center frequency of the carrier by the amount of the maximum frequency of the modulating signal. In transmitting this prior art radio frequency modulated carrier, sufficient bandwidth must be allocated to transmit both the carrier frequency and at least one of the sidebands. Thus, another radio frequency carrier must be spaced at least f_m away from f_c to insure interference free communication.

Figure 2 shows a simplistic example of an amplitude modulated carrier without sidebands. Two levels are chosen for the modulating signal: level A and level B. In the time domain, one sinewave has a period corresponding to the frequency of the carrier f_c. The carrier frequency is fixed at f_c and modulated such that every other complete sinewave is either at level A or level B. Although the amplitude of this time domain signal varies between level A and level B, the frequency never varies since the amplitude is changed upon the zero crossing of the carrier signal. The frequency domain energy spectra is also shown in Figure 2 with the center

frequency energy varying between point A and point B. Since the switching of amplitudes occurs at the zero crossing frequency, no other frequency components are found in the energy spectra and the upper sidebands and the lower sidebands are eliminated. As will be described more fully below, this modulating frequency is selected to be at the most one-half the frequency of the carrier which would be the maximum modulating frequency allowed under the Nyquist criteria to retrieve the modulating signal upon demodulation. As will be described more fully below, it is preferable that the maximum modulating signal frequency be not more than ten percent of the carrier frequency to insure extremely accurate reproduction of the original modulating signal.

With the carrier frequency centered at f_c in Figure 2, and with no sidebands, multiple carrier frequencies can be spaced extremely close without interfering. Since they are pure amplitude modulated carriers without sidebands, the effective use of the available communications spectrum is extremely efficient. As is described more fully below, the close packing of AM RF carrier frequencies in a communications spectrum is limited only by the digital resolution of the modulating circuit, the tolerances of the equipment used and the demodulating circuit. Experimental results have shown that the carrier frequencies can be spaced as close as 200 hertz at any RF carrier frequency without interfering.

DIGITAL MODULATION OF A DIGITALLY PRODUCED CARRIER

Figure 3 is a block diagram of zero sideband amplitude modulation circuit of a preferred embodiment of the present invention. A key component of this circuit is read-only memory (ROM) 304. ROM 304 contains at least two digital representations of a sinewave. The two digital representations contain an identical number of

points and have an identical period; however, the peak amplitude of the first digital representation of the sinewave has a different peak amplitude than the second digital representation of the sinewave. In mapping the digital representations onto the ROM memory locations, it is convenient to describe the first digital representation of a sinewave having a first amplitude as located in the first page of ROM 304. The second digital representation of a sinewave having a second amplitude is conveniently described as located in the second page of memory.

A digital modulation signal 312 is applied to the circuit and is generated by conventional means. For example, the digital modulation signal could be a multi-bit width digitized audio signal, PCM data, binary serial data, etc. For purposes of this simplistic illustration in Figure 3, we will assume that the digital modulation signal is a single-bit serial bit stream of zeros and ones only.

The digital modulation signal 312 will select either the first page or the second page in ROM 304. For example, a zero on the digital modulation signal line 312 will select the first page having a first digital representation of a sinewave having a first amplitude. In a like fashion, a one on digital modulation signal line 312 will select the second page having a second digital representation of a sinewave of a second amplitude. The selection between pages is synchronized using latch 305 which in turn presents the page address to the B-address line of ROM 304. Latch 305 ensures that the next page is not selected until the last page selected has been completely read out of ROM 304. This is effected by zero crossing detector 306 triggering latch 305.

The A-address on ROM 304 selects the individual bit of the digitized representation of the sinewave in the

selected page in a time-sequence manner. If the A-address of ROM 304 sequentially steps through all addresses of a selected page, the entire digital representation of the sinewave for that selected page will be serially presented on the data output line 313 of ROM 304. Data output line 313 outputs a multi-bit word of digital data, each word representing an amplitude level at a specific time point on the digitized sinewave.

Figure 4 shows a simple digital representation of a sinewave having a particular amplitude. This sinewave is not drawn to scale (having only 16 bits peak-to-peak amplitude resolution and having only 16 bits period resolution), and is used for illustration purposes only. Referring to Figure 4 in conjunction with Figure 3, the digitized representation of the sinewave of Figure 4 would be contained in a single page of ROM 304. Each point shown along the horizontal axis in the digital representation of the sinewave of Figure 4 represents a memory address in the selected page of ROM 304. The amplitude of each particular bit is represented by a multi-bit word at the aforementioned address. For example, address zero would represent the zero time point on the digital representation of the sinewave of Figure 3. The amplitude at zero time would also be zero; thus, the multi-bit word selected out of ROM 304 from address zero would be all zeros indicating a zero amplitude out (also indicating a zero crossing of the carrier).

The next sequential address could be a 0001 presented to the A-address into the selected page of ROM 304 which would produce a 0011 amplitude value on data output line 313 of ROM 304. Thus, sequentially stepping from address 0000 to address 1111 on the A-address line of ROM 304 is equivalent to moving in time along the horizontal axis of the digital representation of the sinewave shown in Figure 4. As each sequential address

is selected on A-address line, a multi-bit, parallel word representing the amplitude of the sinewave will be presented on the data output. This multi-bit word on data output 313 is used to drive the digital to analog convertor 307. A digital word presented to the input of the digital to analog convertor 307 will produce a stairstep analog voltage value on its output representative of the digital value presented to the input. The output of digital to analog convertor 307 is presented to a smoothing filter 308 to smooth the stairstep transitions between levels into a smooth sinusoid signal. The signal is presented from filter 308 to RF amplifier 309 and then broadcast by antenna 310.

In order to insure that the page switching accomplished by digital modulation signal 312 occurs only at the zero crossing of the digital representation of the sinewave, a zero crossing detect circuit 306 is used to control latch 305 so that the new page address is only presented once the previous digital representation of the sinewave is read out of data output 313. Zero crossing detect circuit may be a comparator that monitors for a zero data value on the output of 313 which indicates the signal is passing through the zero axis shown in Figure 4 at either the half-sine or full-sine point. Zero crossing detector 306 may also be a logical sign-change detector or it's function may be built into the ROM.

Figure 5 is a digital representation of a sinewave having an amplitude value different from the digital representation of the sinewave in Figure 4. The digital representation of the sinewave in Figure 5 may be found in the second page of memory of ROM 304 while the digital representation of the sinewave of Figure 4 may be found in the first page of ROM 304. Note the different amplitude values for the same addresses between the digital representation of the sinewaves of Figures 4 and 5. Thus, when the digital modulation signal 312 selects

the first page, the peak amplitude of the digital representation of the sinewave will reach a digital value of 0111 on the positive going portion of the sinewave at address 0100. In contrast to this, a zero value on digital modulation signal line 312 will select the second page shown in Figure 5 which will have a lower peak digital value 0101 on the positive going portion of the digital representation of the sinewave at address 0100.

The RF output from the circuit of Figure 3 will be a single carrier frequency which will either have a peak amplitude corresponding to the peak amplitude of the digital representation of the sinewave of Figure 4 or the peak amplitude found in the digital representation of the sinewave in Figure 5. The output will select between the sinewaves or Figures 4 and 5 depending on the values on the digital modulation signal 312. The switching between the sinewaves occur only at the zero crossings so that the frequency and period of the carrier never varies.

Referring once again to Figure 3, the additional blocks will be described. Thus far we have assumed that the A-address of ROM 304 is stepped sequentially from address 0000 through address 1111. The rate at which the A-address lines are sequentially stepped will determine the carrier frequency eventually produced on antenna 310. The carrier frequency can be modified, however, if the rate at which A-address sequentially changes. Register 303 is clocked by a master clock which controls the base carrier frequency. The carrier frequency, however, can be modified by selecting a non-zero value for carrier frequency register 301. If carrier frequency register contains a 1 value, that value will be added to the output of register 303. The output of phase adder 302 drives register 303 such that the feedback loop between phase adder 302 and register 303 causes an increment to be implemented every time master clock 311 clocks register 303. In this fashion, register 303 causes the

A-address on ROM 304 to sequentially step through the addresses of the selected page.

If carrier frequency register 301 contained the value 2, however, phase adder 302 would cause register 303 to increment by 2 for every clock signal received from master clock source 311. Thus, in this fashion, a value of 2 in carrier frequency register 301 would cause the A-address to step by 2's through the addresses of the selected page. This would double the carrier frequency and cause ROM 304 to step through a single sinewave at twice the original frequency. Increasing the value in carrier frequency register 301 would increase the effective carrier frequency output on antenna 310.

Until this point in the detailed description of the preferred of embodiment, simplistic examples of the digital representation of the sinewaves in only two pages of ROM 304 have been given. In an alternate preferred implementation of the preferred embodiment of the present invention, A-address is an 8-bit address allowing for 256 time increments for the digital representation of the sinewaves shown in Figures 4 and 5. Those skilled in the art will readily recognize that in order to cover a broad frequency range of carrier frequencies, a larger A-address would be preferred such as a 16 bit address allowing for 65,536 incremental time positions on the digital representation of the sinewaves shown in Figures 4 and 5 and a 16-bit B-address allowing for 65,536 amplitude variations (pages). Also in a preferred implementation of the preferred embodiment of the present invention, register 303 is a 30 bit register using only the most significant 8 bits of that register to drive A-address on ROM 304. In this fashion, large numbers in carrier frequency register 301 will increment register 303 at increasing rates, however, since the most significant bits of a 30 bit register are used, more

control over the variation in carrier frequency is achieved.

Also in an alternate preferred implementation of the preferred embodiment of the present invention, 256 pages of digital representations of sinewaves are contained in ROM 304. Having 256 pages of digital representations of sinewaves allows for 256 different amplitude levels. Thus, B-address may be an 8-bit wide word selecting one of the 256 pages of memory. In this fashion, the digital modulation signal 312 could, in reality, be an 8-bit word representing 1 of 256 values of an analog signal. The digitization of an analog signal to create the digital modulation signal is well within the skill of the art.

One of the many direct applications to the zero sideband amplitude modulation system of Figure 3 would be the digital transmission of digital audio such as the type found on compact discs. The variations on transmission techniques using the preferred embodiment of the present invention are manifold. One example would be to use a 16-bit parallel word value for the digital modulation signal 312. This 16-bit word value would correspond to the 16-bit value of one side of the stereo digital signal from a compact disc player. Using the output of a CD player to directly drive the digital modulation signal for the preferred embodiment shown in Figure 3 would allow the direct transmission of CD encoded music on a zero sideband AM carrier. To insure accurate resolution, a corresponding high resolution digital to analog convertor 307 would be required to generate the plural amplitude sinewave signals.

Another advantage of the preferred embodiment of the present invention shown in Figure 3 is the immunity from noise. Noise reduction circuitry could be implemented in the receivers for this system which would detect amplitude variations between the single cycle sinewaves on the carrier which would exceed predefined limits.

Noise spikes tend to occur within a single cycle of a carrier. In prior art amplitude modulated signals, this additional noise power is added to the spectrum and results in a noisy demodulated signal. In the preferred embodiment of the present invention, however, the slew rate of the digital modulated signal could be pre-selected to be within defined limits. Any change between amplitudes of successive sinewaves in the carrier signal would indicate the addition of noise if the additional power were outside the pre-defined limits set by the slew rate on the digital modulation signal 312. Such a spurious shift in modulation amplitude would be ignored by the receiver thus eliminating the noise. In such a fashion, the information transmitted digitally by amplitude modulation would be free of noise and the demodulated signal would be as pure as the digital data input at the modulator. Thus, in the example given above, compact disc quality information could be transmitted with the present system over an extremely narrow bandwidth having only amplitude modulation and decoded free of noise. In a preferred implementation of the preferred embodiment of the present invention, limitations on the quality of the components and 256 bit resolution of the addresses of ROM 304 produced a zero sideband signal which varied in center frequency of less than 200 hertz at a 10 megahertz output signal. The accuracy of drift about the center frequency of the carrier is limited only by the quality of the components and the bit resolution of the digital registers.

The present invention will produce an amplitude modulated signal that can be decoded using the present day AM receivers without modification. Since the present amplitude modulation receivers receive the entire power envelope centered about the carrier frequency, all of the power of the carrier frequency will be received by the receiver and properly decoded. The tuning sections of

present day AM receivers, however, receive a very broad spectrum about the carrier frequency, typically 20 kilohertz on the broadcast AM band in North America. Thus, although present day AM receivers may receive and decode the zero band amplitude modulated signals produced by the preferred embodiment of the present invention, this would only be possible if the carrier signals produced are spaced at least 20 kilohertz apart. A complete reallocation of the AM broadcast band would be possible if receivers were adapted to more narrowly receive only the carrier frequencies. Given the benchmark tests of center frequency drift off carrier of only 200 hertz for the present invention, 100 high quality broadcast carrier frequencies could be allocated within the bandwidth currently allocated for a single AM broadcast band. Thus, using even medium quality components, at least a 100-fold increase in the available spectrum for amplitude modulation broadcast are now possible. Commercial, private and military applications of this 100 fold increase in available bandwidth are manifold.

Figure 6 shows an example of plural carrier frequencies in the frequency domain allocated only 200 hertz apart transmitting high quality information free of noise. The information on these carriers could be digitally encrypted to insure the information contained in the signal is not transparent. Having plural adjacent signals, for example, transmitted concurrently could present false information hiding the identity or location of the true information. Thus, some of the carrier frequencies could be jamming frequencies shielding the true location of the information. In a similar fashion, if the frequencies were transmitted concurrently, the digitally encrypted information could be distributed in a spread spectrum fashion between the different carriers in different time slots thus also hiding the true location

of the data or spreading the location of data around according to an encrypted key.

Figure 7 shows a modulation system equipped to modulate zero sideband AM, conventional AM, or FM. ROM 601 contains plural pages of digital representations of sinewaves. If one were to select a single page and modulate the rate at which the time axis of the digital representation of the sinewave is addressed, digital frequency modulation (FM) would be the result. If one were to set the frequency at which the address into the digital representations was incremented and only modulate the page address, amplitude modulation would result on the same carrier. By modulating both the page address in ROM 601 and the rate at which the A-address is incremented, both amplitude modulation and frequency modulation could be the result. The digital modulation of amplitude or frequency would be the result of a single modulation signal or two separate modulation signals could be transmitted FM and AM concurrently on the same RF carrier. The digital representations of sinewaves could be stored as single sideband signals or double sideband signals for conventional AM transmissions. Also, CW could be transmitted by always selecting the same page.

The operation of the zero sideband modulation system of Figure 7 is similar to the description accompanying Figure 3. Frequency register 602 fixes the base carrier frequency as described above. This base frequency, however, can be modulated by the digital modulation signal 603 for FM synchronized by latch 608. The synchronized digital modulation signal on line 615 is added or subtracted (depending on the positive or negative value described by modulation signal 603) with the output of frequency register 602. The output of modulation adder 604 is used as an increment value to drive phase adder 605. Phase adder 605 combines the

increment value for modulation adder 604 with the result of address register 606. Master clock 607 clocks the address register 606 at a fixed frequency to synchronize the application of addresses to ROM 601. Figure 8 is a block diagram of a zero side band modulation system 800 of an alternate preferred embodiment of the present invention. Block 801 is a digital source having a an n-bit wide output representative of, for example, digitized audio. The output of digital modulation source 801 is driven into latch 802 which is used to synchronize the application of the digital modulation data to ROM 809. The zero crossing synchronization signal for latch 802 is received from the ROM which could be generated in a number of forms. For example, the zero crossing signal could be encoded in the ROM data of the digitized representation of the sinewave or external logic could be used to detect a sign change in the data. The synchronized digital modulation data from latch 802 is applied to modulation selector 803. This modulation selector 803 is used to select whether the modulator 800 is to produce amplitude modulation with no sidebands or conventional modulation with sidebands (AM with sidebands, FM, CW, SSB, etc.). The "C" input to ROM 809 is a control input used to select between ZSB (zero sideband) and conventional modulation.

The "N" input into ROM 809 is an n-bit wide modulation signal which is used to select the page having a specific amplitude of a digital representation of a sinewave corresponding to the n-bit digital modulation signal where n is selected depending upon the amplitude resolution required and the number of pages that can be held in memory.

Frequency register 804 is a digital register which contains the digital information necessary to generate the carrier frequency. The frequency register is user

selectable depending upon the carrier center frequency desired.

The output of frequency register 804 drives modulation adder 805 which is only used for generating conventional modulation signals. Modulation selector 803 drives modulation adder 805 with the n-bit digital modulation signal synchronized by latch 802 if modulation selector 803 is selecting conventional modulation. If conventional modulation is not selected out of modulation selector 803, the n-bit wide signal driving modulation adder 805 from modulation selector 803 is set to zero corresponding to ZSB.

Modulation adder 805 has the effect of either increasing or decreasing the phase angle of the carrier signal upon generation since it will cause some bits on the time axis to be skipped when the output of modulation adder 805 increases. The modulation adder 805 adds the n-bit value from modulation selector 803 with the f-bit value from frequency register 804. In one implementation of the preferred embodiment of the present invention, n may be 16 bits as in the case of digital audio from a compact disc system. Also, for example, f may be a 30 bit wide value.

The result of the addition of the n-bit value and the f-bit value through modulation adder 805 is an f-bit value increased or decreased by n if conventional modulation were selected. If zero side band modulation were selected, the f-bit value of modulation adder 805 would be the same as the f-bit value output from frequency register 804.

Phase adder 806 and adder register 807 combine to form a feedback loop to increment the address "M" driving ROM 809. "M" corresponds to the time (horizontal) axis of the digital representation of the sinewave in the page of memory selected by "N" in ROM 809 (as shown in Figures 4 and 5). The output of phase adder 806 is an f-bit

value which is the combination of an f-bit value from adder register 807 and an f-bit value from modulation adder 805. Adder register 807 is incremented by master clock 808. Each time the master clock increments adder register 807, a new f-bit value is loaded. The new value loaded into adder register 807 is a combination of the previous value added to the increment f-bit value from modulation adder 805. The resulting f-bit value from adder register 805 is typically a 30-bit value in a preferred implementation, with the most significant 8 bits used as an address into ROM address input "M". The m-bit "M" address increments through the digital representation of the sinewave for the selected page at a speed selected by the combination of frequency register 804, modulation adder 805, phase adder 806 and adder register 807 incremented by master clock 808. In this fashion, a wide variety of incrementation rates through the digital representation of the sinewave is available for producing RF carriers for zero sideband modulation or conventional modulation such as side band AM or side band FM.

The data bit width of output "Q" is selected depending upon the required resolution of the modulation carrier signal. In the preferred embodiment, 10 bits is selected for the q-bit signal "Q". The data output "Q" is synchronized with the addressing circuitry by master clock 808. Latch 810 is used for synchronizing the outgoing data to insure a clean generation of a signal from ROM 809.

Digital to analog convertor 811 is driven by the q-bit signal from latch 810 synchronized by master clock 808. The analog output from digital to analog convertor 811 is filtered by filter 812 to smooth the stairstep sinewave output from digital to analog convertor 811 to insure a smooth sinusoidal output. The output of filter

812 is used to drive RF amplifier 813 which in turn broadcasts the signal via an antenna.

Figure 9 shows a simplified block diagram of a communication system for transmitting and receiving information utilizing the teachings of the present invention. A very basic form of a zero sideband amplitude modulation system is shown in the left of Figure 9 for transmitting either digital modulation data 914 or digitized analog information 913 (such as digitized voice, digitized music, digitized video, digitized FAX, etc.). The analog information must be digitized using analog to digital convertor 908. The digital modulation data is used to select the page into ROM 904 to select a particular sinewave amplitude to correspond to the value of the digital information. A selector 909 is shown in Figure 9 allowing the selection of digital or digitized analog sources. The output of selector 909 drives a synchronizing latch 902 which allows the digital modulation data 914 or the digitized analog information 913 to be applied to the page input to ROM 904 upon the zero crossing of the carrier sinewave as detected by zero crossing detector 903. In this fashion, the sinewave magnitude values for the selected pages are changed only upon the zero crossing detected on the data output of ROM 904.

The frequency of the carrier is selected by clock 915. This clock signal shown in Figure 9 is a fixed RF frequency selected by the user depending upon the medium and requirements for transmission and reception. The clock frequency is selected to be m times the desired RF carrier frequency where m is the number of bits on the time axis for one complete cycle of the digitized sinewave held in ROM 904. Counter 901 is a free running ring counter which is clocked by clock 915 to continuously count up until reaching its maximum value and start at zero again. The output of ring counter 901

drives the address input to ROM 904. In this fashion, the sinewave magnitude values for the selected page are sequentially addressed on ROM 904 presenting a digital sinewave on the data output of ROM 904.

The data output of ROM 904 drives the digital to analog convertor 905 and the zero crossing detector 903. The digitized sinewave is converted by digital to analog convertor 905 into a stairstep analog signal which is filtered by filter 906 to smooth the stairsteps. The sinewave carrier is applied to RF amplifier 907 and broadcast via antenna 920.

Receiving antenna 921 receives the electromagnetic energy of the zero sideband amplitude modulated carrier signal and is applied to a convention radio detector 910. The detector 910 recovers the modulating signal in either an analog or digital form depending on the application for the radio receiver. The signal from detector 910 is applied to amplifier 911 which produces the digital or analog output 912. Digitized audio on the input 913 would be recovered as an analog output 912. A digital source 914 applied to the transmitter portion of the system 990 would require an analog to digital convertor 916 to recover the digital data on the output 917.

Communication system 991 shown in Figure 10 is similar to the communication system 990 shown in Figure 9 except the medium of communication is now by satellite uplink and downlink. Satellite uplink 930, for example, could be used in place of a conventional radio transmitter. The satellite uplink could be used to transmit single carrier per channel (SCPC), zero sideband amplitude modulated data or digitized analog signals to be rebroadcast by satellite 932. The preferred embodiment of the present invention would create zero sideband amplitude modulated carriers at extremely narrow frequencies such that a SCPC transmission system utilizing satellite 932 would occupy a minimum amount of

bandwidth greatly increasing the existing capacity of our satellite transmission systems. Satellite downlink 931 would receive the single carrier per channel information relayed by satellite 932 and would demodulate the signal in a conventional fashion as already described.

The communication system 992 of Figure 11 is similar to the system 990 shown in Figure 9 except the medium of transmission has been changed. In this example, a fiber optic transmission and reception system is used to relay the zero sideband amplitude modulated carrier. Fiber optic transmitter 940 receives the modulated carrier from amplifier 907 and transmits it via fiber optic link 942(a) across a land-based path. The far end of fiber optic link 942(b) connected to 942(a) would receive the modulated carrier and convert it from an optical signal to an electrical signal for detection by detector 910. Demodulation would occur as previously described.

Figure 12 describes a communication system 993 which is similar to the communication system 990 shown in Figure 9 except a wire land-based communication medium 950 is used. Aero sideband carrier modulation and demodulation is as described above. Those skilled in the art will readily recognize that a wide variety of terrestrial and freespace communication systems could be used with the preferred embodiments of the present invention.

Figure 13 shows a pictorial description of a memory mapping which could be used for the ROM in the preferred embodiment of the present invention. A plurality of digital representations of sinewaves is shown assigned to pages 1 through n. Each page of memory is selected based upon the digital modulation signal applied to the ROM. For example, 256 pages could be allocated in the ROM providing 256 discrete amplitude levels for the digital representation of the sinewaves. Depending upon the modulation value, a sinewave having a particular

amplitude would be selected. Each sinewave within all of the pages in the memory have the same period and the same number of points along the sinewave. The only difference between the pages is the amplitude of the points along each sinewave. For example, the maximum amplitude during the first half sine of the digital representation of the sinewave of page 1 would be a small digital value. In contrast to this, the maximum amplitude during the first half sine of the digital representation of the sinewave found in page n would be a large digital value, possibly the maximum allowed. In a preferred implementation of the present invention the number of pages is selected to be 256. Thus the digital modulation signal is selected to be 8 bits wide. Within each page, there are 256 digital points along the time axis of the digital representation of the sinewave. This would require an 8-bit address into the ROM to select the time point along the curve. Each amplitude or magnitude value of the sinewave in each page is selected to be an 8-bit value representing the magnitude. Thus, the data output of the ROM is an 8-bit wide word. Thus, 256 pages of 256 8-bit words would require a 64K ROM (65,536 bits).

In the preferred embodiments of the present invention, the highest RF carrier frequency is limited only by the speed of the digital logic used to implement the circuits. Standard TTL logic easily achieves an RF carrier of 5 MHz. Standard ECL logic produces an RF carrier exceeding 50 MHz while GaAs (Gallium Arsenide) produces RF carriers in excess of 500 MHz. Those skilled in the art will readily recognize that newer high speed digital logic will achieve RF carrier frequencies well into the GHz range.

CIRCUIT IMPLEMENTATION OF CARRIER MODULATION WITHOUT SIDEBANDS

Figures 14 through 18 are detailed electrical schematic diagrams of a circuit implementation of carrier

modulation without sidebands. The figures should be viewed together and are connected via the signal names.

Circuit U1 is a processor chip which produces, among other things, the digital modulation data. In this implementation, the processor has the digital modulation data stored in processor memory for use in modulating the carrier. Modulation data, of course, could be received from an external source but in this implementation the modulation data is a stored pattern. Processor chip U1 is in the preferred implementation a 70320 processor available from NEC and other sources.

Chips U2 and U3 in Figure 14 are ROM and RAM storage chips respectively. U2 is, in the preferred implementation, part number 27C512 which is a UV erasable 512K prom arranged as 64K by 8 bits. This chip is available through Intel and other semi-conductor vendors. RAM chip U3 is, in the preferred implementation, a 43 256 CMOS static RAM chip arranged as 37,768 by 8 bits. RAM chip U3 is available from NEC and other semi-conductor vendors. ROM and RAM chips U2 and U3 are used as processor support chips for the processor based modulation system of Figures 14 through 18.

The base frequency is generated by counter chip U4 on Figure 15. A crystal oscillator with the selected frequency shown is connected to the clock input of counter U4 which is, in the preferred embodiment, part number 74F163 available from Texas Instruments and other vendors. The clocking frequencies, F1 - F5 are available for controlling the circuit. U4 is then the counter used for generating the main carrier frequency.

Registers U8, U9 and U10 are the phase registers fed from the processor chip U1. The three phase register circuits include three additional support chips, the arrangement of which are identical as shown in Figures 17 and 18. All chips have their part numbers shown and are

available from Texas Instruments and other semiconductor vendors.

Referring to Figure 18, phase register chip U10 is connected to 4 bit binary full adders U16 and U15 which sum the four bits A1 - A4 with B1 - B4 to produce summation results E1 through E4. The summation results from chips U16 and U15 are latched in register chip U19 which is also part number 74LS374. These results are fed back for summation through full adder chips U16 and U15. The configurations for phase registers U9 and U8 of Figure 17 are the same for that described above.

The carry bits from the full adders U11, U12, U13, U16 and U17 are connected to carry the results of the low ordered bits of the full adders through to the high order bits of the full adders to create an ADD ladder chain.

U5 is a decoder chip attached to the processor U1 and also to phase registers U8, U9 and U10 used to select and control those registers. Phase registers U8, U9 and U10 are used to determine the frequency or to select the frequency of the carrier. The most significant 8 bits of the adder chips feed the address lines on ROM chips U20 and U21 which are also, in the preferred implementation, UV erasable PROM's identical to ROM U2.

ROM chips U20 and U21 contain the digital representation of sinewaves contained in individual pages of memory which are serially read out and applied to digital to analog (D/A) convertor U23 through the upper 12-bits of latch chips U25 and U26 respectively. These latch chips are, in the preferred embodiment, 74F374 identical to the latch chips described above. D/A convertor chip U23 is a 12 bit resolution D/A convertor available through a plurality of vendors. In the alternative, D/A convertor chip U23 could, in an alternative implementation, be a stairstep smoothing filter used to sum and smooth the stepped digital data from latch chips U25 and U26. The latch chips are

synchronized with clock frequencies F1 from the crystal oscillator X1.

The most significant bit from ROM chip U21 (DIG15) is used as a zero crossing signal to drive latch chip U24 which synchronizes the application of the digital data P2-0 through P2-7 from processor chip U1 to lines A00 - A07 of the address bus as it applies to the page inputs A0 - A7 on ROM chips U20 and U21 in Figure 18. In this fashion, the signal DIG15 is used as the zero crossing signal to synchronize the application of the digital data to select the page addresses of the digital representations of sinewaves contained in ROM chips U20 and U21.

The output of D/A convertor U23 is driven through a simple smoothing filter comprised of the discreet component shown in Figure 16 and out a co-axial connector J2. An RF amplifier and antenna can be connected to co-axial connector J2 (not shown).

Additional support chips shown, for example, is Figure 15 are buffers U60 - U62 and U70 - U72 which buffer control signals to and from the microprocessor to a simple external communication bus used in this preferred implementation to download control information to the zero sideband carrier circuit.

<u>ANALOG MODULATION OF A DIGITALLY PRODUCED CARRIER</u>

Figure 19 is a block diagram of a communication system for accomplishing analog modulation of a digitally produced carrier to produce carrier modulation without sidebands. The generation of a carrier frequency through ROM chip 410 is similar to that described above in conjunction with Figures 3 through 13 except a single page of memory is used for a single amplitude digital representation of a sinewave. A master clock 403 is used to synchronize the operation of the circuit. A frequency register 401 is preloaded with the desired RF carrier

frequency continually counted up by adder register 405 and phase adder 402. The counting frequency is used to address the individual data points of the digital representation of the sinewave in ROM 410 through address line 404. The multi-bit digital data output from ROM 410 is synchronized to the master clock 403 through latch 411. The output of the digital data is presented to D/A convertor 413 on line 412.

The analog modulation signal source 406 may be from a wide variety of sources including audio, voice, video and other sources. The signal source is applied to sample and hold circuit 409 which is used to sample and capture the analog value at a particular point in time. The sample and hold circuit 409 is controlled by zero detect circuit 408 which detects when the stairstepped analog output of D/A convertor 413 crosses the zero point. Zero crossing detector circuit 408 then controls the sampling of the analog source and presents it to the reference input 417 of D/A convertor 413. As is well known to those skilled in the art, changing the reference voltage on a D/A convertor will change the amplitude of the output of that D/A convertor. Normally the reference input to D/A convertors is held at a fixed level while the data signals change values. In this implementation, changing of the reference line 417 will cause the amplitude to change at the zero crossing, hence producing a modulated carrier having zero sidebands. The output of D/A convertor 413 is applied to smoothing filter 414, and RF amplifier 415 to be broadcast by antenna 416. In an alternate implementation, the output of the sample and hold circuit 409 is applied to the gain stage of amplifier 415 (as described below in conjunction with Fig. 20) to change the amplitude of the radio frequency carrier only at the zero crossing point.

DIGITAL MODULATION OF AN ANALOG CARRIER

Figure 20 is a block diagram of a method and apparatus for digital modulation of an analog RF carrier to produce carrier modulation without sidebands. A digital modulation source 501 may be a single bit or multi-bit digital modulation signal representative of digitized audio, digitized voice, data, digitized video and other digital or digitized information to be transmitted. The digital data is applied to latch circuit 502 which is synchronized with zero detect circuit 504. The analog RF signal source 505 may be from known sources such as a crystal oscillator. The fixed RF signal is applied to zero detect circuit 504 for detecting the zero crossing of the carrier. Upon zero crossing of the carrier, latch circuit 502 captures the digital value of the digital modulation signal. The output of latch circuit 502 is applied to D/A convertor 503 which is used to change the amplification factor of RF amplifier 506 only at the zero crossing. The amplification factor of an amplifier can be changed by a wide variety of methods. For example, in the use of a feedback loop, the amplification may be changed by changing the amount of feedback between the output and the input. Also, some amplifiers are equipped with a voltage reference input which, when changed, changes the amplitude of the output signal. Other methods of changing the amplitude of an RF amplifier are known to those in the art.

The fixed amplitude analog RF signal is applied to RF amplifier where it is digitally modulated by changing the amplification of RF amplifier 506 only upon the zero crossing of the carrier. Thus, output of RF amplifier 506 when applied through antenna 507 produces carrier modulation without sidebands.

Figure 22 is a block diagram of a method and apparatus for digital modulation of an analog RF carrier

to produce carrier modulation without sidebands of an alternate embodiment. A digital modulation source 511 may be a single bit or multi-bit digital modulation signal representative of digitized audio, digitized voice, data, digitized video and other digital or digitized information to be transmitted. The digital data is applied to latch circuit 512 which is synchronized with zero detect circuit 514. The analog RF signal source 515 may be from known sources such as a crystal oscillator. The fixed frequency RF signal is applied to zero detect circuit 514 for detecting the zero crossing of the carrier. Upon zero crossing of the carrier, latch circuit 512 captures the digital value of the digital modulation signal. The output of latch circuit 512 is applied to the analog RF signal source 515 which changes the amplitude of the oscillator output only at the zero crossing. The amplitude of an oscillator can be changed by a wide variety of methods. For example, some oscillators are designed using a voltage reference which, when changed, changes the amplitude of the output signal. Other methods of changing the amplitude of an oscillator are known to those in the art.

ANALOG MODULATION OF AN ANALOG CARRIER

Figure 21 is a block diagram of an implementation of carrier modulation without sidebands by analog modulation of an analog RF signal source only upon the zero crossing. An analog modulation signal source 701 may be comprised of a variety of analog sources of information such as audio, voice, video and other sources. The analog modulation signal source is applied to sample and hold circuit 702 where the analog value at any given point in time is sampled and captured by that circuit. The analog value is then presented on the output of sample and hold circuit 702. An analog RF signal source 705 may be a crystal oscillator and other sources of RF

energy. RF signal source 705 is a fixed frequency fixed amplitude energy source. The output of RF signal source 705 is monitored by zero detect circuit 703 for the zero crossing of the RF signal. Every time the RF signal crosses the zero point, zero detect circuit 703 causes sample and hold circuit 702 to capture the analog value of the analog modulation signal source 701. The output of sample and hold circuit 702 is applied to RF amplifier 706 to change the amplification factor of that amplifier. As described above, the RF amplifier will change its amplification factor by a number of methods including varying the feedback on the amplifier and varying the reference. The output of amplifier 706 is applied to antenna 707 where the RF modulated signal is broadcast without sidebands.

Figure 23 is a block diagram of an implementation of carrier modulation without sidebands by analog modulation of an analog RF signal source only upon the zero crossing of an alternate embodiment. An analog modulation signal source 711 may be comprised of a variety of analog sources of information such as audio, voice, video and other sources. The analog modulation signal source is applied to sample and hold circuit 712 where the analog value at any given point in time is sampled and captured by that circuit. The analog value is then presented on the output of sample and hold circuit 712. An analog RF signal source 715 may be a crystal oscillator and other sources of RF energy. Analog RF signal source 715 is a fixed-frequency energy source. The output of RF signal source 715 is monitored by zero detect circuit 713 for the zero crossing of the RF signal. Every time the RF signal crosses the zero point, zero detect circuit 713 causes sample and hold circuit 712 to capture the analog value of the analog modulation signal source 711. The output of sample and hold circuit 712 is applied to the analog RF signal source 715 which changes the amplitude

of the oscillator output only at the zero crossing. The amplitude output of an oscillator can be changed by a wide variety of methods. For example, some oscillators are designed using a voltage reference which, when changed, changes the amplitude of the output signal. Other methods of changing the amplitude of an oscillator are known to those in the art. The output of amplifier 716 is applied to antenna 717 where the RF modulated signal is broadcast without sidebands.

CARRIER INFORMATION

Referring once again to Figure 2, those skilled in the art will readily recognize that the ability to change the amplitude of an RF carrier upon the zero crossing produces zero sidebands since analog multiplication of an analog carrier is no longer necessary. The amount of information such a carrier may contain is enormous. In the prior art, the Nyquist Criteria described how modulated carriers could accurately carry only a modulation signal having at most one-half the carrier frequency. With the present invention, the carrier frequency could also be modulated by a modulation signal less than, equal to or of a higher frequency than the carrier signal. Referring once again to Figure 2, level A may represent a digital value of zero while level B may represent a digital value of 1. In this fashion, the digital transmission rate of the RF modulated carrier is equal to one-half the frequency of the RF carrier. If one were to encode the different amplitude levels with ternary, catenary or n-ary signals, the carrier frequency could actually carry plural-bit values within each cycle of the carrier. In addition, if the radio frequency detector of a receiver could accurately predict the zero base line, the positive going sinewaves could be encoded with one modulation signal while the negative going cycles of the sinewaves could be encoded with a second

signal. In such a fashion, plural signals at frequencies higher than the carrier frequency could be encoded in a single carrier frequency without sidebands.

It is recognized that complete zero sideband modulated carriers are not always possible due to the inaccuracies of the components used. Those skilled in the art, however, will recognize that extremely limited sidebands may be produced due to the imperfections of the components used to implement the preferred embodiments of the present invention.

Those skilled in the art will readily recognize that other circuitry may be used to implement digital modulation of a digital carrier, analog modulation of a digital carrier, digital modulation of an analog carrier and analog modulation of a digital carrier to produce carrier modulation without sidebands.

Those skilled in the art will readily recognize that a wide variety of memories could be substituted for the ROM including RAM, register stored in a microprocessor, PLA or PAL data, hardwired data, memory stored in an application specific integrated circuit (ASIC), and other digital memory storage While the present invention has described connection with the preferred embodiment thereof, it will be understood that many modifications will be readily apparent to those of ordinary skill in the art, and this application is intended to cover any adoptions or variations thereof. Therefore, it is manifestly intended that this invention be limited only by the claims and the equivalents thereof.

WHAT IS CLAIMED:

1. A method of amplitude modulation, comprising:

(a) selecting a first amplitude of a carrier frequency and transmitting said carrier frequency at said first amplitude; and

(b) switching said carrier frequency to a next amplitude at the zero crossing of the carrier frequency and transmitting said carrier frequency at said second amplitude.

2. A communication system, comprising:

(a) means for producing a carrier frequency having a first amplitude;

(b) means for producing a carrier frequency at a second amplitude; and

(c) means for switching the carrier frequency from the first amplitude to the second amplitude at a zero crossing of the carrier frequency in response to a digital modulation signal.

3. An amplitude modulated signal comprising a first carrier sinewave having a first amplitude followed at the zero crossing by second carrier sinewave having a second amplitude.

4. A method of modulating a radio frequency carrier with a modulating signal, comprising the steps of:

(a) producing a gating signal corresponding to the zero crossing point of a radio frequency carrier;

(b) gating the modulating signal with said gating signal to produce a gated modulating signal; and

(c) modulating the radio frequency carrier with said gated modulating signal and producing a modulated radio frequency carrier therefrom.

5. The method according to claim 4 wherein said step of modulating operates to change the amplitude of the modulated radio frequency carrier only at the zero crossing of the carrier.

6. The method according to claim 4 further including the step of transmitting the modulated radio frequency carrier through a medium.

7. The method according to claim 6 wherein said step of transmitting is accomplished by broadcasting and wherein said medium is the air waves.

8. The method according to claim 6 wherein said step of transmitting is accomplished by light and wherein said medium is a fiber optic link.

9. The method according to claim 6 wherein said step of transmitting is accomplished by electric transmission and wherein said medium is a wire.

10. The method according to claim 6 wherein said medium includes a communications satellite.

11. The method according to claim 4 wherein said modulating signal is a digital signal.

12. The method according to claim 4 further including generating said radio frequency carrier, comprising the additional steps of:

(a) sequentially addressing a memory device at a predefined rate;

(b) reading digital data from said memory device at said clocking rate, said digital data corresponding to predefined amplitude levels of a time varying signal;

(c) converting said digital data into a time varying analog signal; and

(d) smoothing said time varying analog signal to produce the radio frequency carrier.

13. The method according to claim 12 wherein said time varying signal is a sinusoid.

14. The method according to claim 12 wherein said predefined rate is selected to be a multiple of the frequency of the radio frequency carrier.

15. A method of producing an amplitude modulated radio frequency carrier having no sidebands, comprising the steps of:

(a) sequentially addressing the address port of a memory device at a predetermined rate;

(b) selectively reading a first set of digital data from said memory device at said rate, said first set of digital data corresponding to predefined amplitude points of a first time varying sinusoid having a first amplitude;

(c) selectively reading a second set of digital data from said memory device at said rate, said second set of digital data corresponding to predefined amplitude points of a second time varying sinusoid having a second amplitude, the period of said second time varying sinusoid being equal to and coinciding with the period of said first time varying sinusoid;

(d) producing a synchronizing signal corresponding to the zero crossing point of said time varying sinusoids;

(e) receiving a modulating signal;

(f) synchronizing said modulating signal with said synchronizing signal to produce a synchronized modulating signal;

(g) selecting between said first set of digital data and said second set of digital data in response to said synchronized modulating signal;

(h) converting the selected one of said first set of digital data and said second set of digital data into a time varying analog signal; and

(i) smoothing said time varying analog signal to produce an amplitude modulated radio frequency carrier.

16. The method according to claim 15 further including the step of transmitting the amplitude modulated radio frequency carrier through a medium.

17. The method according to claim 16 wherein said step of transmitting is accomplished by broadcasting and wherein said medium is the air waves.

18. The method according to claim 16 wherein said step of transmitting is accomplished by light and wherein said medium is a fiber optic link.

19. The method according to claim 16 wherein said step of transmitting is accomplished by electric transmission and wherein said medium is a wire.

20. The method according to claim 16 wherein said medium includes a communications satellite.

21. The method according to claim 15 wherein said predefined rate is selected to be a multiple of the frequency of the amplitude modulated radio frequency carrier.

22. The method according to claim 15 wherein said modulating signal is a digital signal.

23. A method of modulating a radio frequency signal with a modulating signal, comprising the steps of:

producing a first time varying radio frequency signal having a first amplitude;

producing a second time varying radio frequency signal having a second amplitude, said second time varying radio frequency signal being in phase with and having the same period as said first time varying radio frequency signal;

selecting either said first or said second time varying radio frequency signal only at the zero crossing point of said signals in response to a modulation signal.

24. An apparatus for modulating a radio frequency carrier with a modulating signal, comprising:

means for producing a gating signal corresponding to the zero crossing point of a radio frequency carrier;

means for gating the modulating signal with said gating signal and for producing a gated modulating signal therefrom; and

means for modulating the radio frequency carrier with said gated modulating signal and for producing therefrom a modulated radio frequency carrier.

25. The apparatus according to claim 24 further including means for transmitting the modulated radio frequency carrier through a medium.

26. The apparatus according to claim 25 wherein said medium is the air waves.

27. The apparatus according to claim 25 wherein said medium is a fiber optic link.

28. The apparatus according to claim 25 wherein said medium is a wire.

29. The apparatus according to claim 25 wherein said medium includes an artificial communications satellite.

30. The apparatus according to claim 25 wherein said modulating signal is a digital data signal.

31. The apparatus according to claim 24 further including means for generating said radio frequency carrier, said means for generating comprising:

means for sequentially addressing a memory device at a predefined rate;

means for reading digital data from said memory device at said rate, said digital data corresponding to predefined amplitude levels on a time varying signal;

means for converting said digital data into a time varying analog signal; and

means for smoothing said time varying analog signal to produce the radio frequency carrier.

32. The apparatus according to claim 31 wherein said time varying signal is a sinusoid.

33. The apparatus according to claim 31 wherein said predefined rate is selected to be a multiple of the frequency of the radio frequency carrier.

34. A zero side band modulation apparatus, comprising:

frequency source means for generating an addressing signal;

modulations input means for receiving a digital modulation signal;

synchronization means connected to said modulation input means for synchronizing said digital modulation signal in response to a zero crossing detect signal and for producing a synchronized digital modulation signal;

memory means having a first address port connected to said frequency means, having a second address port connected to said synchronization means and having a data output, said memory means for storing a plurality of digital representations of sine waves each having different amplitudes, and for selectively producing on said data output one of said digital representations of sine waves in response to receiving said addressing signal on said first address port and said synchronized digital modulation signal on said second address port;

detector means connected to said data output of said memory means for detecting the zero crossing of said selected digital representations of sine waves and for producing therefrom said zero crossing detect signal;

convertor means connected to said data output means of said memory means for converting said selected digital representations of sine waves into time varying analog signals;

filter means connected to said convertor means for smoothing the time varying analog signals and for producing therefrom an amplitude modulated radio frequency carrier having substantially zero sideband energy.

35. A zero side band modulation apparatus, comprising:

first sine wave means for producing a first digital representation of a sinusoid having a first amplitude;

second sine wave means for producing a second digital representation of a sinusoid having a second amplitude;

select means connected to said first sine wave means and said second sine wave means for selecting between said first digital representation of a sinusoid and said second digital representation of a sinusoid in response to a synchronized modulation signal;

zero detect means connected to said first sine wave means and said second sine wave means for detecting the zero crossing of said first digital representation of a sinusoid and said second digital representation of a sinusoid;

modulations input means for receiving a modulation signal; and

synchronization means connected to said modulation input means and said zero detect means for synchronizing said modulation signal and for producing said synchronized modulation signal.

36. The apparatus according to claim 35 further comprising:

convertor means connected to said select means for converting said selected ones of said first and second digital representations of a sinusoid into time varying analog signals; and

filter means connected to said convertor means for smoothing the time varying analog signals and for producing therefrom an amplitude modulated radio frequency carrier having substantially zero sideband energy.

37. A radio transmitter, comprising:

first register means for producing an incrementing digital value corresponding to a desired carrier frequency;

phase adder means connected to said carrier frequency register for receiving said incrementing digital value and connected to a second register for receiving an incremented sequential addressing value, said phase adder means operable for adding said incrementing digital value to said incremented addressing value and for producing therefrom a rate of change value;

clock means for producing a master clock signal;

said second register means connected for receiving said master clock signal and said rate of change value and for producing therefrom said incremented sequential addressing value;

memory means having a first address input connected to said second register means for receiving said incremented sequential addressing value, having a second input address port connected to a synchronization latch for receiving a

synchronized digital modulation signal, and having a data output;

said memory means further operable for storing a plurality of digital representations of sine waves having different amplitudes and for producing on said data output selected ones of said digital representations of sine waves in response to said rate of change value and in response to said synchronized digital modulation signal;

means for receiving a digital modulation signal;

said synchronization means connected for receiving said digital modulation signal and a zero crossing detect signal and for producing therefrom said synchronized digital modulation signal;

detector means connected to said data output means for detecting the zero crossing of said selected digital representation of said sine waves and for producing therefrom said zero crossing detect signal;

convertor means connected to said data output means for converting said digital representations of said sine waves into time varying analog signals;

filter means connected to said convertor means for smoothing said time varying analog signal;

amplifier means connected to said filter means for amplifying said time varying analog signals; and

transmitting means connected to said amplifier means for broadcasting said time varying analog signal.

38. A method of modulating a radio frequency carrier with an analog modulating signal, comprising the steps of:

(a) producing a gating signal corresponding to a zero crossing point of a radio frequency carrier;
(b) gating the analog modulating signal with said gating signal to produce a gated modulating signal; and
(c) modulating the radio frequency carrier with said gated modulating signal and producing a modulated radio frequency carrier therefrom having substantially zero sidebands.

39. The method according to claim 38 wherein said radio frequency carrier is digitally produced.

40. The method according to claim 39 further including generating said radio frequency carrier, comprising the additional steps of:
(a) sequentially addressing a memory device at a predefined rate;
(b) reading digital data from said memory device at said predefined rate, said digital data corresponding to a predefined time varying signal;
(c) converting said digital data into a time varying analog signal; and
(d) smoothing said time varying analog signal to produce the radio frequency carrier.

41. The method according to claim 40 wherein said step of modulating further includes applying the gated modulating signal to the reference input of a digital-to-analog converter to change the amplitude of the radio frequency carrier at the zero crossing point.

42. The method according to claim 40 wherein said step of modulating further includes applying the gated

modulating signal to the gain stage of an amplifier to change the amplitude of the radio frequency carrier at the zero crossing point.

43. The method according to claim 40 wherein said time varying analog signal is a sinusoid.

44. The method according to claim 40 wherein said predefined rate is selected to be a multiple of the frequency of the radio frequency carrier.

45. The method according to claim 38 wherein said radio frequency carrier is produced as an analog signal.

46. The method according to claim 45 wherein said step of modulating further includes applying the gated modulating signal to the gain stage of an amplifier to change the amplitude of the radio frequency carrier at the zero crossing point.

47. The method according to claim 45 wherein said step of modulating further includes applying the gated modulating signal to a radio frequency oscillator to change the amplitude of the radio frequency carrier at the zero crossing point.

48. A method of modulating an analog radio frequency carrier with a digital modulating signal, comprising the steps of:

(a) producing a gating signal corresponding to a zero crossing point of the analog radio frequency carrier;

(b) latching the digital modulating signal with said gating signal to produce a latched digital modulating signal;

(c) converting the latched digital modulating signal into a latched analog modulating signal; and

(d) modulating the radio frequency carrier with said latched analog modulating signal and producing a modulated analog radio frequency carrier therefrom having substantially zero sidebands.

49. The method according to claim 48 wherein said step of modulating further includes applying the latched analog modulating signal to the gain stage of an amplifier to change the amplitude of the analog radio frequency carrier at the zero crossing point.

50. The method according to claim 48 wherein said step of modulating further includes applying the latched modulating signal to a radio frequency oscillator to change the amplitude of the analog radio frequency carrier at the zero crossing point.

51. The method according to claim 38 further including the step of transmitting the modulated radio frequency carrier through a medium.

52. The method according to claim 51 wherein said step of transmitting is accomplished by broadcasting and wherein said medium is the air waves.

53. The method according to claim 51 wherein said step of transmitting is accomplished by light and wherein said medium is a fiber optic link.

54. The method according to claim 51 wherein said step of transmitting is accomplished by electric transmission and wherein said medium is a wire.

55. The method according to claim 51 wherein said medium includes a communications satellite.

56. The method according to claim 40 wherein said predefined rate is selected to be a multiple of the frequency of the modulated radio frequency carrier.

57. An apparatus for modulating a radio frequency carrier with an analog modulating signal, comprising:

means for producing a gating signal corresponding to the zero crossing point of a radio frequency carrier;

means for gating the analog modulating signal with said gating signal and for producing a gated modulating signal therefrom; and

means for modulating the radio frequency carrier with said gated modulating signal and for producing therefrom a modulated radio frequency carrier having substantially zero sidebands.

58. The apparatus according to claim 57 further including means for producing a radio frequency carrier from a stored digital pattern.

59. The apparatus according to claim 58 wherein said means for modulating the radio frequency carrier further includes:

means for sequentially addressing a memory device at a predefined rate;

means for reading said stored digital pattern from said memory device at said predefined rate, said digital data corresponding to a predefined time varying signal;

means for converting said stored digital pattern into a time varying analog signal; and

means for smoothing said time varying analog signal to produce the radio frequency carrier.

60. The apparatus according to claim 59 wherein said means for modulating further includes means for applying the gated modulating signal to said means for converting to change the amplitude of the radio frequency carrier at the zero crossing point.

61. The apparatus according to claim 60 wherein said means for converting is a digital-to-analog converter having a reference input attached to said means for applying.

62. The apparatus according to claim 59 further including an amplifier attached to said means for smoothing and wherein said means for modulating further includes means for applying the gated modulating signal to the gain stage of said amplifier to change the amplitude of the radio frequency carrier at the zero crossing point.

63. The apparatus according to claim 59 wherein said time varying analog signal is a sinusoid.

64. The apparatus according to claim 59 wherein said predefined rate is selected to be a multiple of the frequency of the radio frequency carrier.

65. The apparatus according to claim 57 wherein said radio frequency carrier is produced as an analog signal.

66. The apparatus according to claim 65 wherein said means for modulating further includes an amplifier and means for applying the gated modulating signal to the

gain stage of said amplifier to change the amplitude of the radio frequency carrier at the zero crossing point.

67. The apparatus according to claim 65 wherein said means for modulating further includes a radio frequency oscillator and means for applying the gated modulating signal to said radio frequency oscillator to change the amplitude of the radio frequency carrier at the zero crossing point.

68. An apparatus for modulating an analog radio frequency carrier with a digital modulating signal, comprising:

means for producing a gating signal corresponding to a zero crossing point of the analog radio frequency carrier;

means for latching the digital modulating signal with said gating signal and for producing a latched digital modulating signal;

means for converting said latched digital modulating signal into a latched analog modulating signal; and

means for modulating the radio frequency carrier with said latched analog modulating signal and for producing a modulated radio frequency carrier therefrom having substantially zero sidebands.

69. The apparatus according to claim 68 wherein said means for modulating further includes an amplifier and means for applying said latched analog modulating signal to the gain stage of said amplifier to change the amplitude of the radio frequency carrier at the zero crossing point.

70. The apparatus according to claim 68 wherein said means for modulating further includes a radio frequency oscillator and means for applying said latched modulating signal to said radio frequency oscillator to change the amplitude of the radio frequency carrier at the zero crossing point.

71. The apparatus according to claim 57 further including means for transmitting the modulated radio frequency carrier through a medium.

72. The apparatus according to claim 71 wherein said means for transmitting includes an antenna and said medium is the air waves.

73. The apparatus according to claim 71 wherein said means for transmitting includes an optical transducer and said medium is a fiber optic link.

74. The apparatus according to claim 71 wherein said means for transmitting includes an amplifier and said medium is a wire.

75. The apparatus according to claim 71 wherein said means for transmitting includes an uplink antenna and said medium includes an artificial communications satellite.

76. A zero side band modulation apparatus, comprising:

modulation input means for receiving an analog modulation signal;

sample means connected to said modulation input means for sampling and holding said analog modulation signal in response to a zero crossing

detect signal and for producing a sampled analog modulation signal;

frequency source means for generating an addressing signal;

memory means having an address port connected to said frequency source means and having a data output, said memory means for storing a digital representation of a sine wave and for producing on said data output said digital representation of a sine wave in response to receiving said addressing signal on said address port;

detector means connected to said data output of said memory means for detecting the zero crossing of said digital representation of a sine wave and for producing therefrom said zero crossing detect signal;

convertor means connected to said data output of said memory means for converting said digital representation of a sine wave into a time varying analog signal; and

filter means connected to said convertor means for smoothing said time varying analog signal and for producing therefrom an amplitude modulated radio frequency carrier having substantially zero sideband energy.

77. A zero side band modulation apparatus, comprising:

oscillator means for producing an analog radio frequency carrier;

zero detect means connected to said oscillator means for detecting the zero crossing of said analog radio frequency carrier and for producing a zero crossing detect signal;

modulation input means for receiving an analog modulation signal;

sample means connected to said modulation input means for sampling and holding said analog modulation signal in response to said zero crossing detect signal and for producing a sampled analog modulation signal; and

amplifier means connected to said oscillator means for amplifying said analog radio frequency carrier, and having a reference input connected for receiving said sampled analog modulation signal and for producing therefrom an amplitude modulated radio frequency carrier having substantially zero sideband energy.

78. A zero side band modulation apparatus, comprising:

oscillator means for producing an analog radio frequency carrier;

zero detect means connected to said oscillator means for detecting the zero crossing of said analog radio frequency carrier and for producing a zero crossing detect signal;

modulation input means for receiving a digital modulation signal;

latch means connected to said modulation input means for latching and holding said digital modulation signal in response to said zero crossing detect signal and for producing a latched digital modulation signal;

conversion means connected to said latch means for converting said latched digital modulation signal to a converted modulation signal; and

amplifier means connected to said oscillator means for amplifying said analog radio frequency carrier and having a reference input connected for receiving said converted modulation signal and for

producing therefrom an amplitude modulated radio frequency carrier having substantially zero sideband energy.

79. A zero side band modulation apparatus, comprising:

oscillator means for producing an analog radio frequency carrier having an amplitude selected in response to a reference input;

zero detect means connected to said oscillator means for detecting the zero crossing of said analog radio frequency carrier and for producing a zero crossing detect signal;

modulation input means for receiving an analog modulation signal;

sample means connected to said modulation input means for sampling and holding said analog modulation signal in response to said zero crossing detect signal and for producing a sampled analog modulation signal; and

said sample means further connected to said reference input of said oscillator means for selecting the amplitude of said analog radio frequency carrier and for producing therefrom an amplitude modulated radio frequency carrier having substantially zero sideband energy

80. A zero side band modulation apparatus, comprising:

oscillator means for producing an analog radio frequency carrier having an amplitude selected in response to a reference input;

zero detect means connected to said oscillator means for detecting the zero crossing of said analog radio frequency carrier and for producing a zero crossing detect signal;

modulation input means for receiving a digital modulation signal;

latch means connected to said modulation input means for latching and holding said digital modulation signal in response to said zero crossing detect signal and for producing a latched digital modulation signal;

conversion means connected to said latch means for converting said latched digital modulation signal to a converted modulation signal;

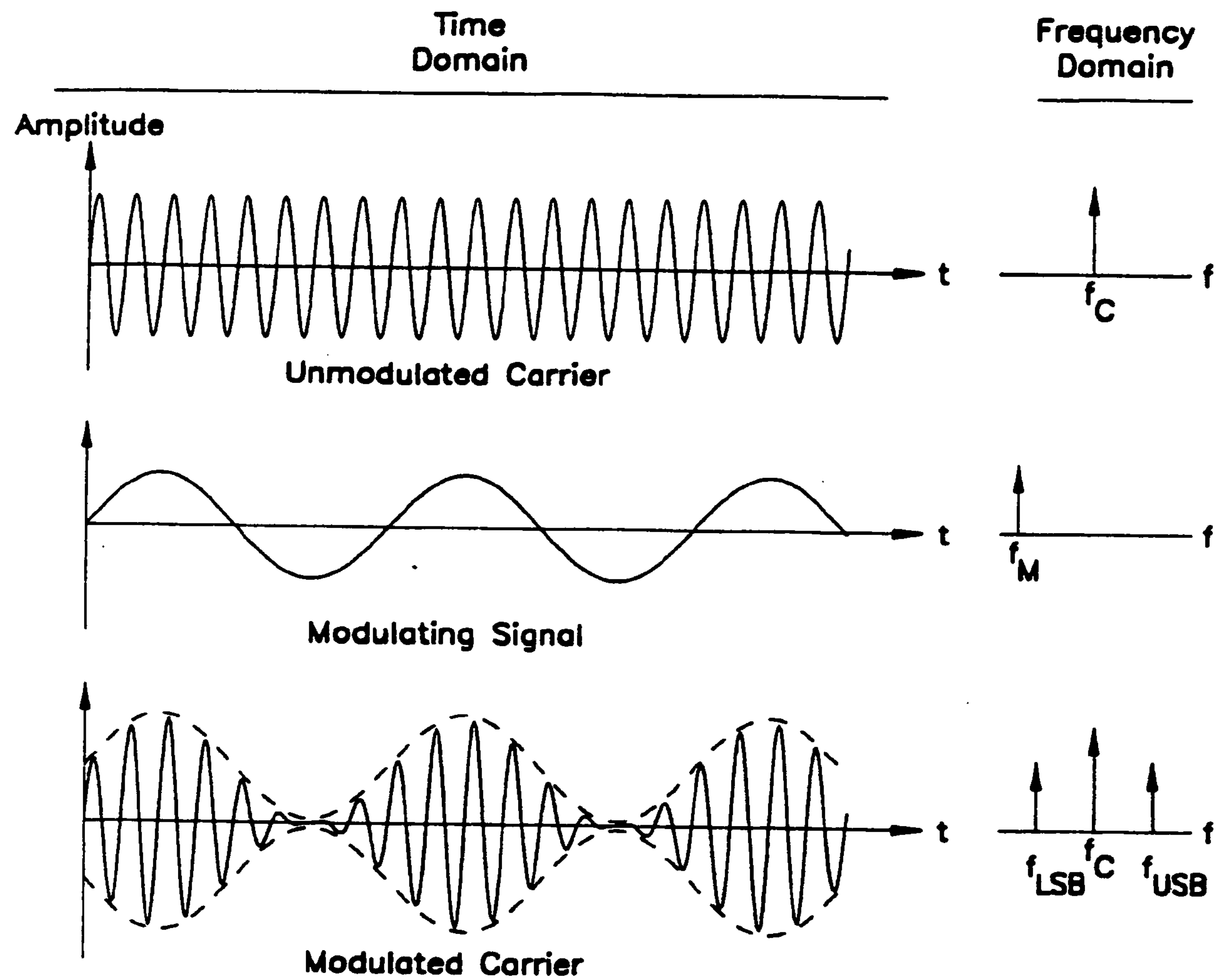
said conversion means further connected to said reference input of said oscillator means for selecting the amplitude of said analog radio frequency carrier and for producing therefrom an amplitude modulated radio frequency carrier having substantially zero sideband energy

81. The method according to claim 38 wherein the frequency of the analog modulating signal is higher than the frequency of the radio frequency carrier.

82. The method according to claim 48 wherein the frequency of the digital modulating signal is higher than the frequency of the analog radio frequency carrier.

83. The apparatus according to claim 57 wherein the frequency of the analog modulating signal is higher than the frequency of the radio frequency carrier.

84. The method according to claim 68 wherein the frequency of the digital modulating signal is higher than the frequency of the analog radio frequency carrier.



Prior Art
FIG. 1

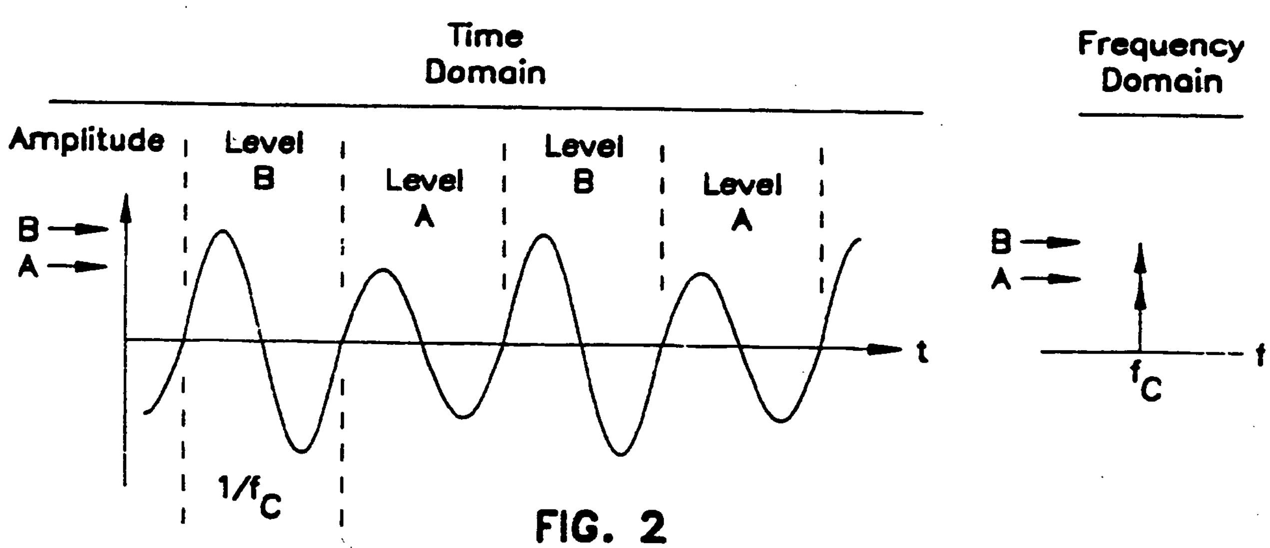


FIG. 2

SUBSTITUTE SHEET

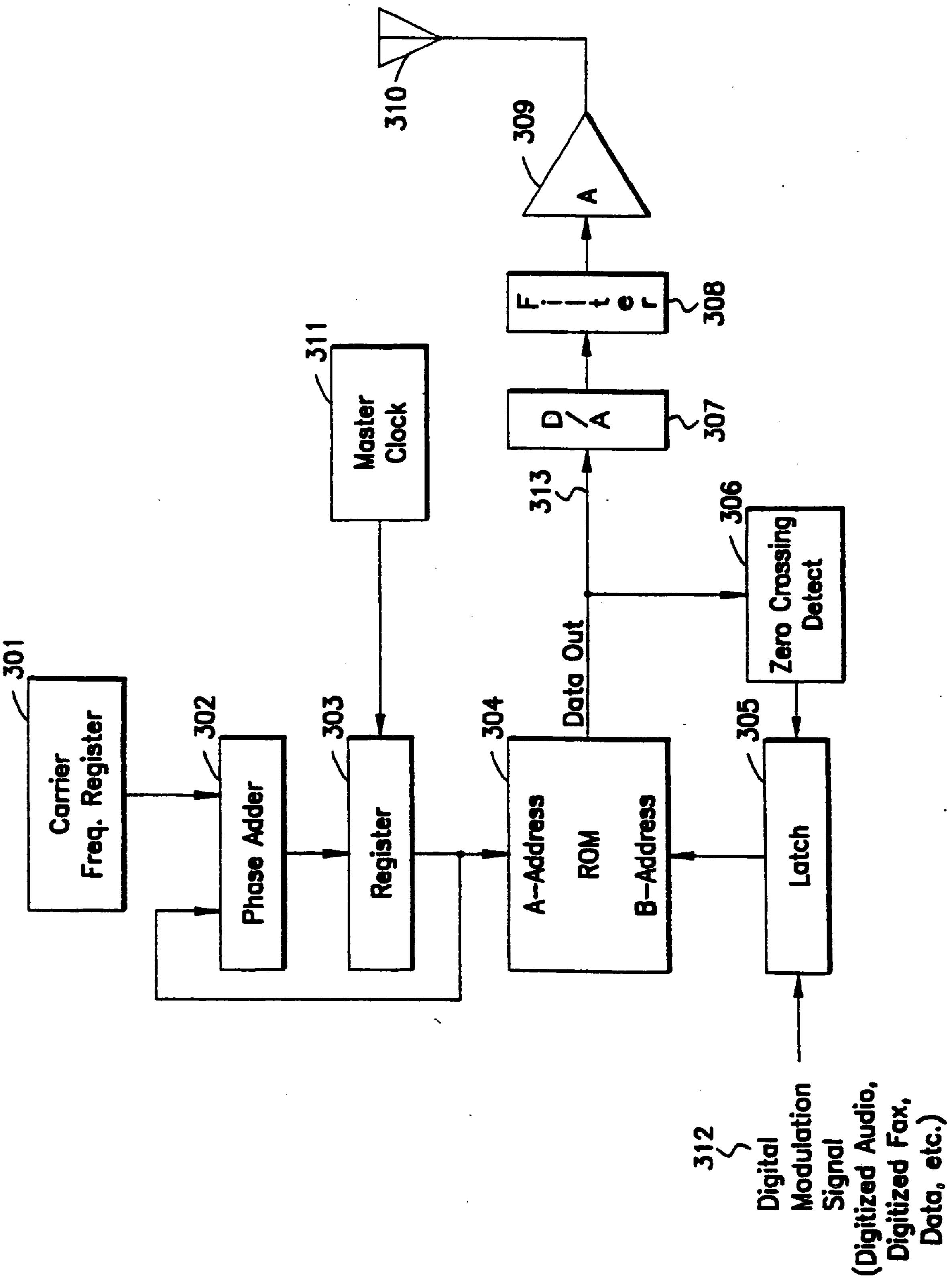

301
Carrier Freq. Register
302
Phase Adder
303
Register
311
Master Clock
304
A-Address
ROM
B-Address
Data Out
313
305
Latch
306
Zero Crossing Detect
307
D/A
308
Filter
309
A
310
312
Digital Modulation Signal (Digitized Audio, Digitized Fax, Data, etc.)

FIG. 3

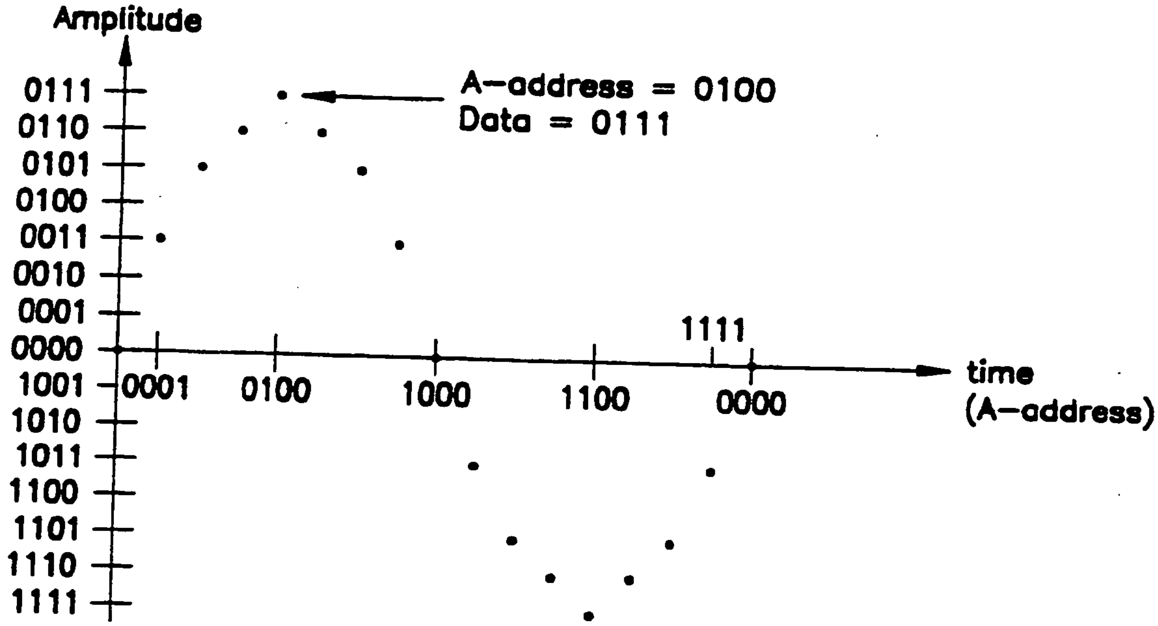


FIG. 4

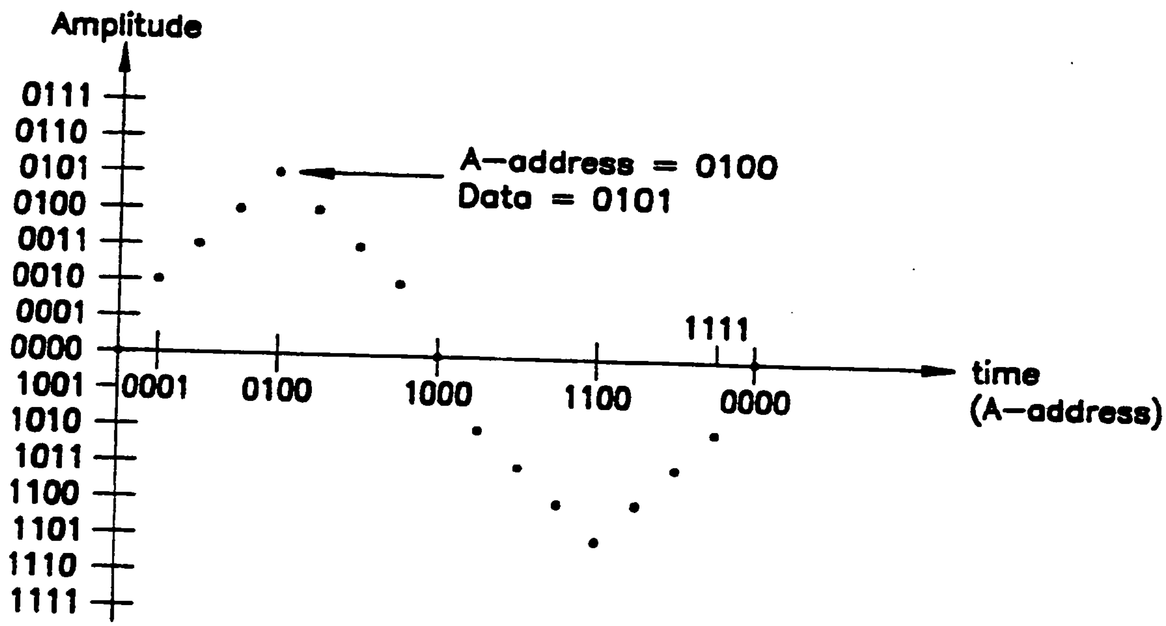


FIG. 5

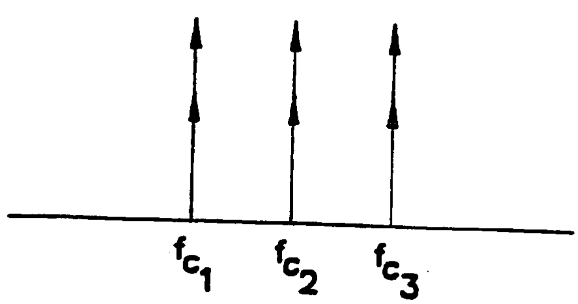


FIG. 6

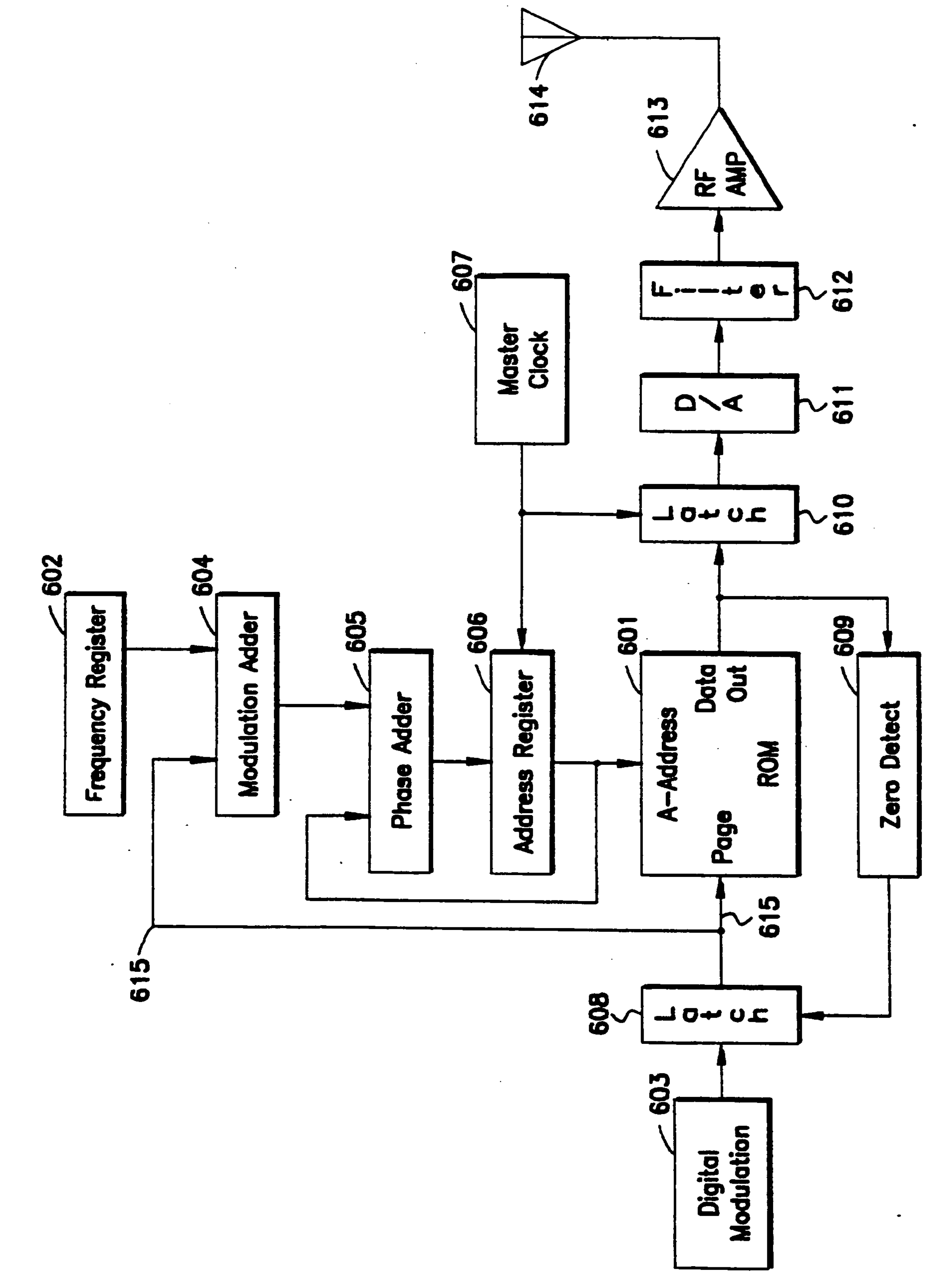

Frequency Register
602
Modulation Adder
604
Phase Adder
605
Address Register
606
Master Clock
607
A-Address
Page
Data Out
ROM
601
Zero Detect
609
Digital Modulation
603
Latch
608
615
615
Latch
610
D/A
611
Filter
612
RF AMP
613
614

FIG. 7

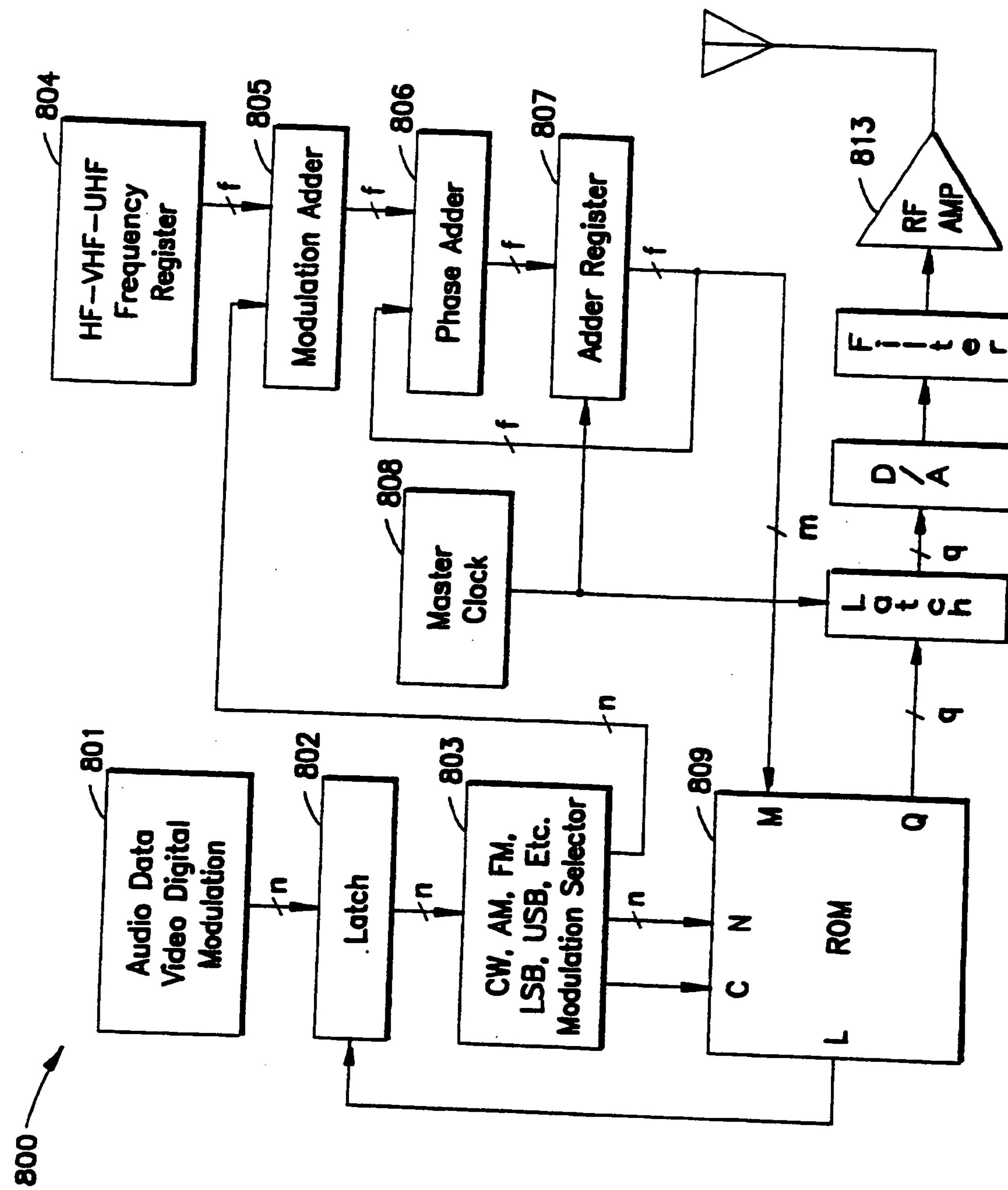

800
801
Audio Data Video Digital Modulation
802
Latch
803
CW, AM, FM, LSB, USB, Etc. Modulation Selector
804
HF–VHF–UHF Frequency Register
805
Modulation Adder
806
Phase Adder
807
Adder Register
808
Master Clock
809
ROM
M
N
C
L
Q
810
Latch
811
D/A
812
Filter
813
RF AMP
n
f
m
q

FIG. 8

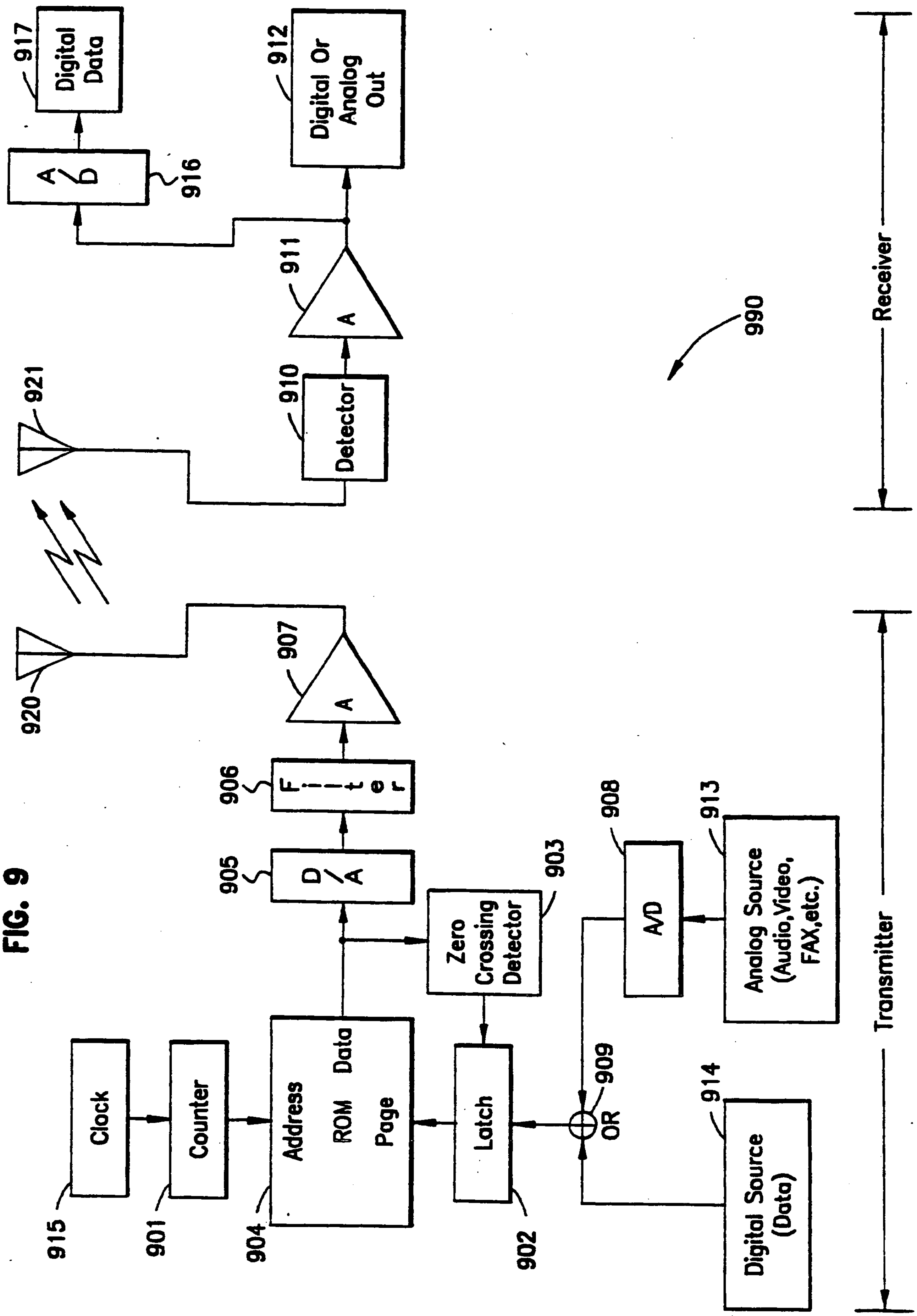

Clock
915
Counter
901
Address
ROM
Data
Page
904
Latch
902
Zero Crossing Detector
903
D/A
905
Filter
906
A
907
920
921
Detector
910
A
911
A/D
916
Digital Data
917
Digital Or Analog Out
912
990
909
OR
A/D
908
Analog Source (Audio,Video, FAX,etc.)
913
Digital Source (Data)
914
Transmitter
Receiver

FIG. 9

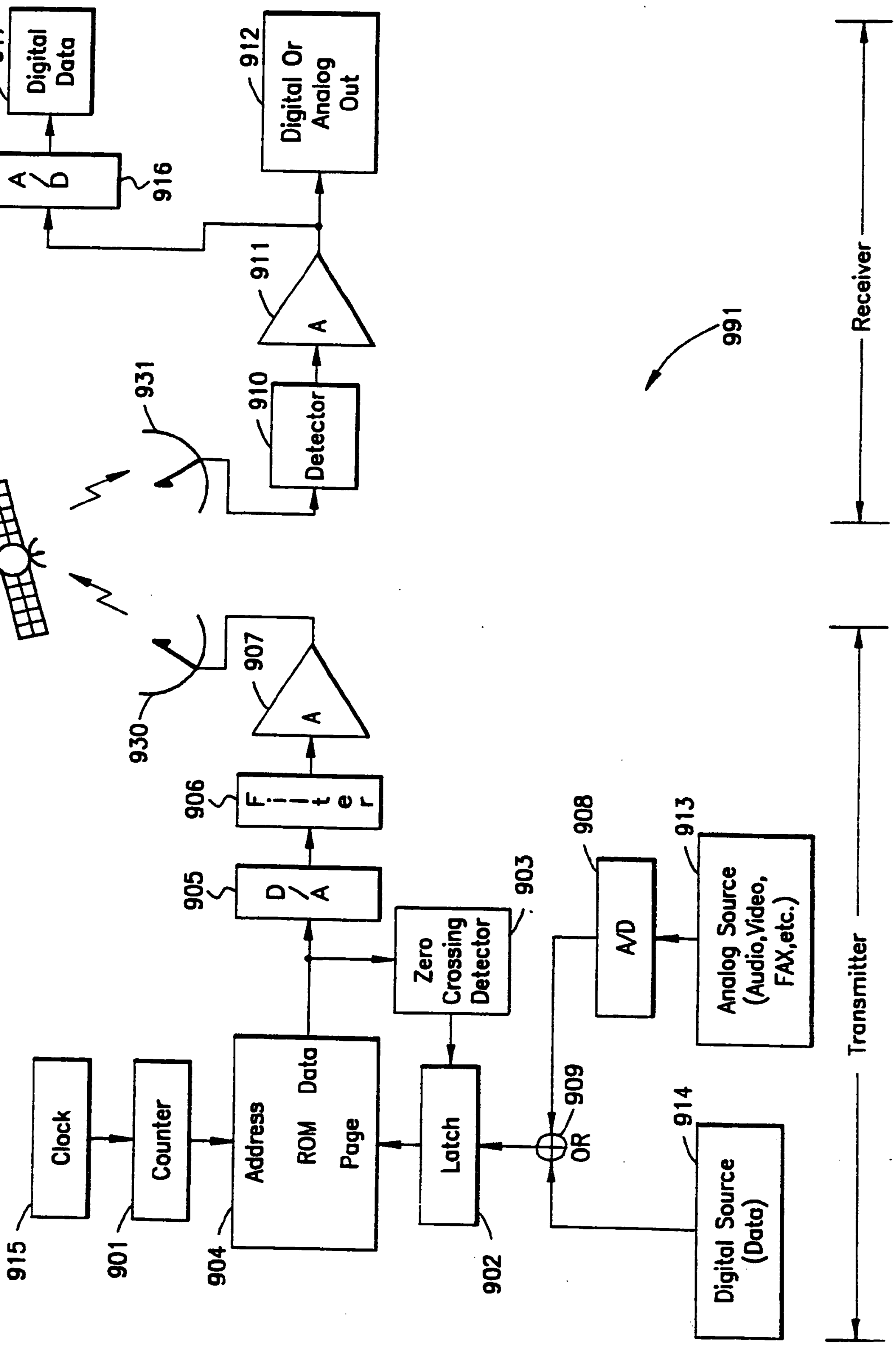
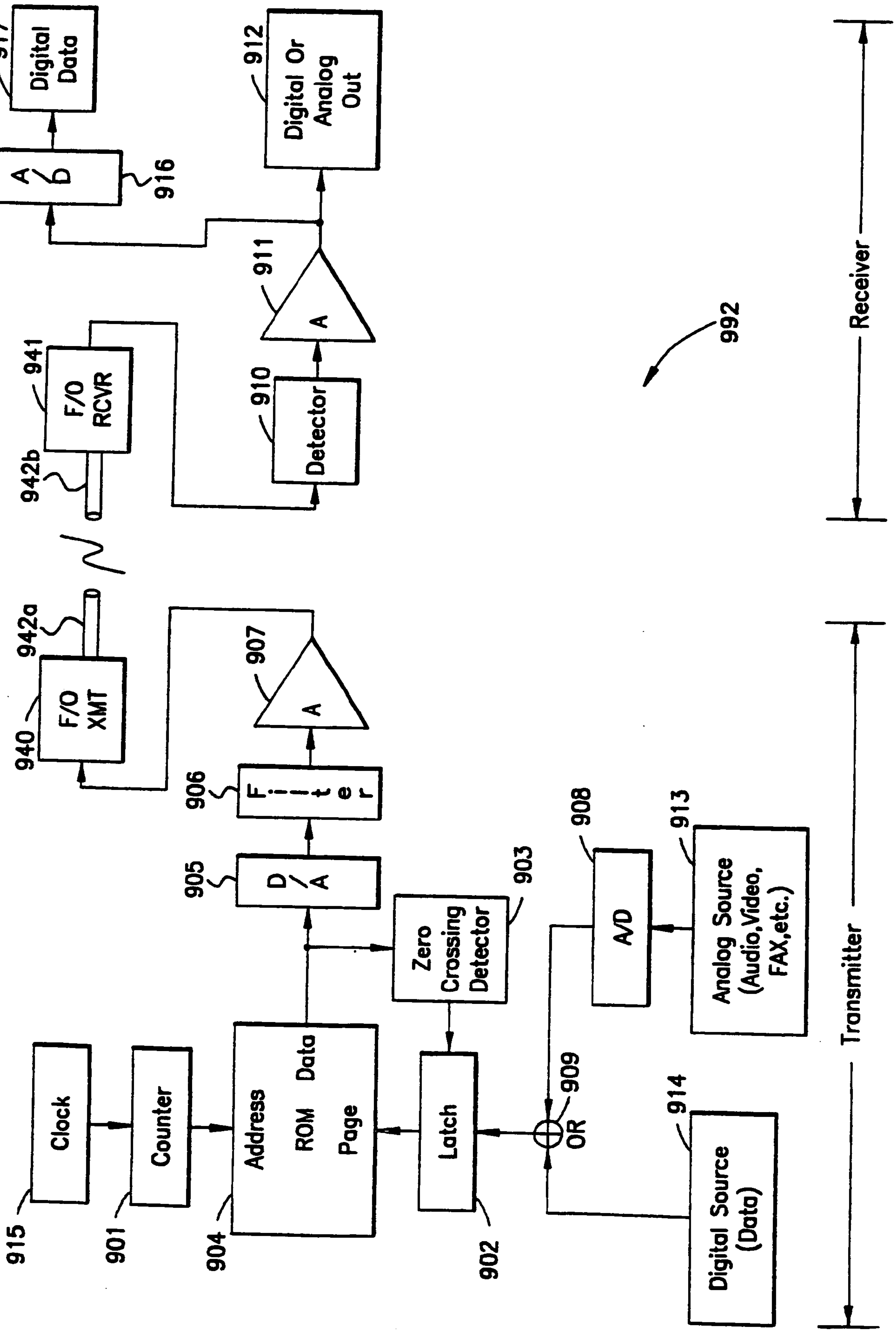

Digital Data
917
A/D
916
Digital Or Analog Out
912
911
A
991
Receiver
932
931
Detector
910
930
907
A
906
Filter
905
D/A
903
Zero Crossing Detector
908
A/D
913
Analog Source (Audio,Video, FAX,etc.)
Transmitter
915
Clock
901
Counter
904
Address ROM Data Page
Latch
902
909
OR
914
Digital Source (Data)

FIG. 10

FIG. 11


Clock
915
Counter
901
Address
ROM
Data
Page
904
Latch
902
OR
909
Digital Source (Data)
914
Zero Crossing Detector
903
D/A
905
Filter
906
A
907
F/O XMT
940
942a
A/D
908
Analog Source (Audio,Video, FAX,etc.)
913
Transmitter
942b
F/O RCVR
941
Detector
910
A
911
992
A/D
916
Digital Data
917
Digital Or Analog Out
912
Receiver

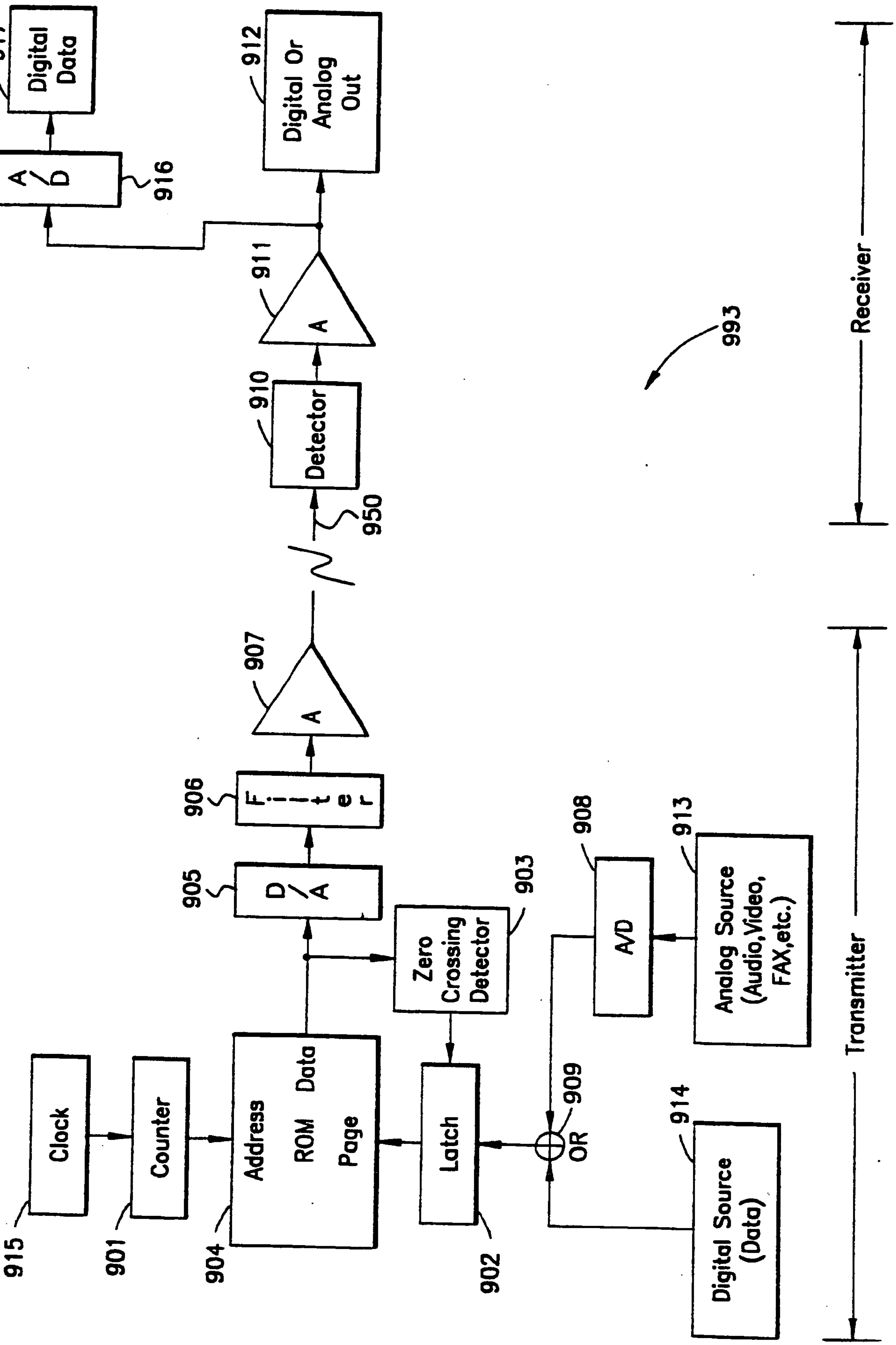

Clock
Counter
Address
ROM Data
Page
Latch
OR
Zero Crossing Detector
D/A
Filter
A
A/D
Analog Source (Audio,Video, FAX,etc.)
Digital Source (Data)
Detector
A
Digital Or Analog Out
A/D
Digital Data
Transmitter
Receiver
915
901
904
902
909
914
913
908
903
905
906
907
950
910
911
912
916
917
993

FIG. 12

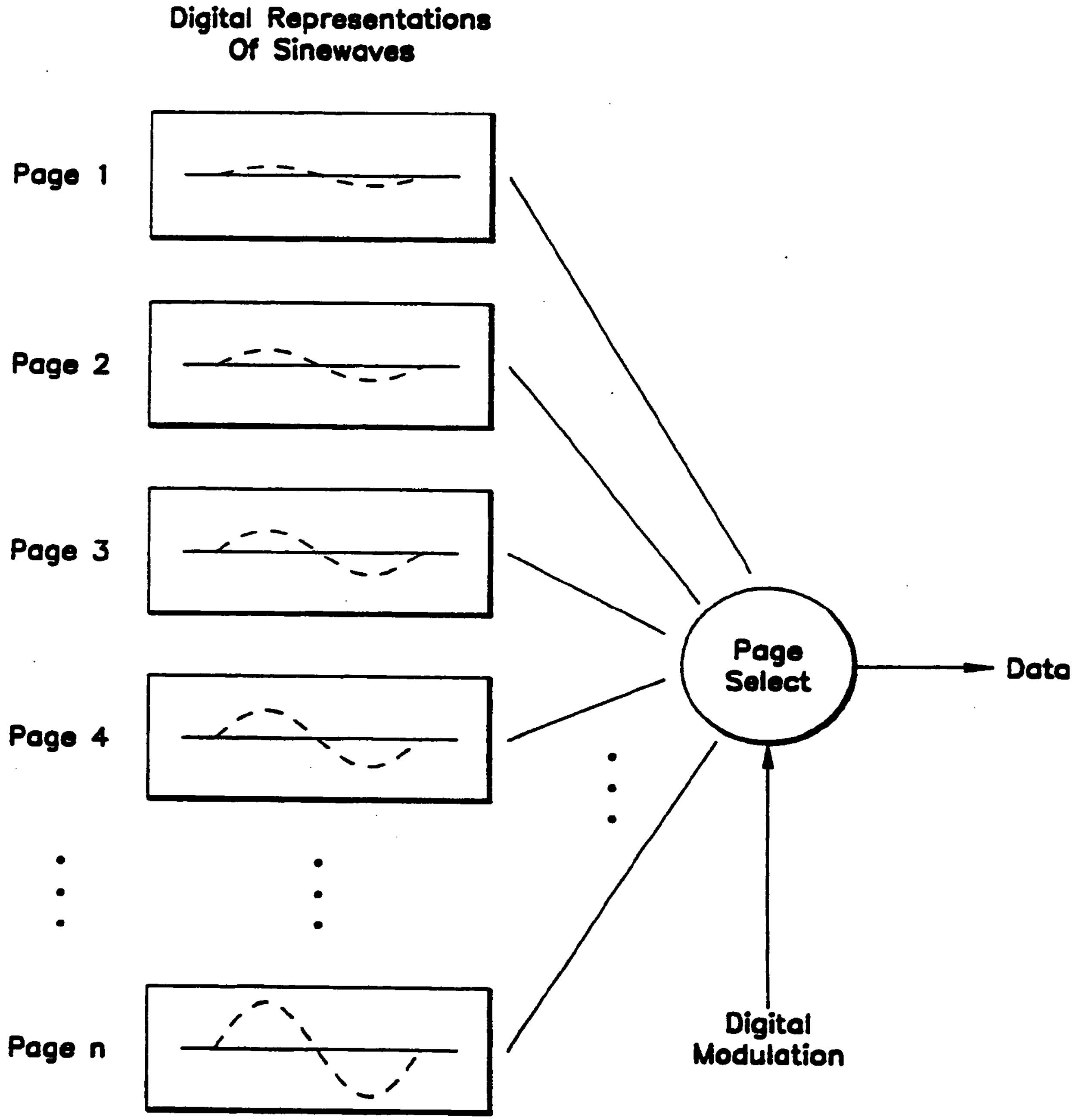

Digital Representations
Of Sinewaves
Page 1
Page 2
Page 3
Page 4
Page n
Page
Select
Data
Digital
Modulation

FIG. 13

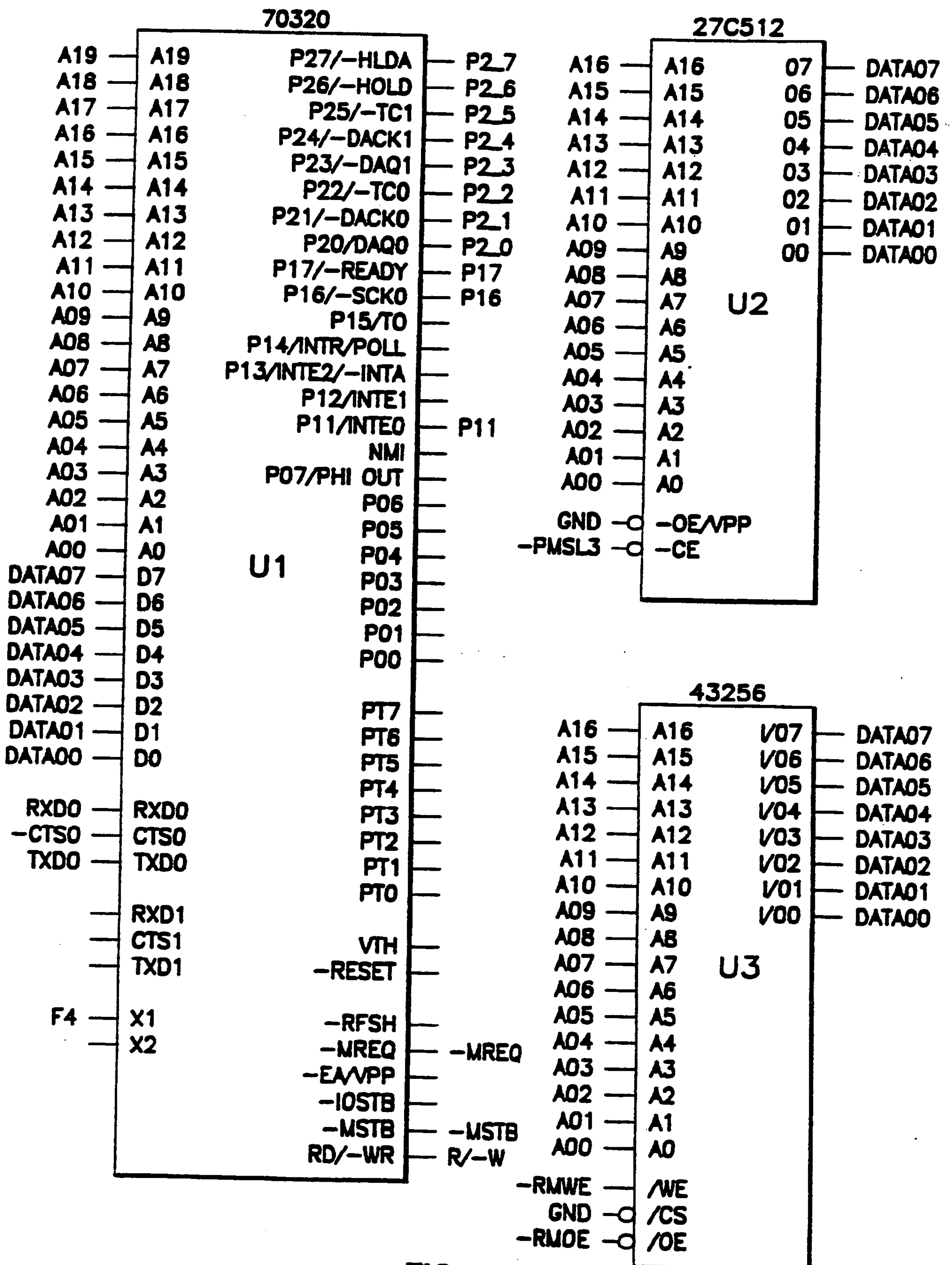

70320
A19 A18 A17 A16 A15 A14 A13 A12 A11 A10 A09 A08 A07 A06 A05 A04 A03 A02 A01 A00
A19 A18 A17 A16 A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0
DATA07 DATA06 DATA05 DATA04 DATA03 DATA02 DATA01 DATA00
D7 D6 D5 D4 D3 D2 D1 D0
RXD0 -CTS0 TXD0
RXD0 CTS0 TXD0
RXD1 CTS1 TXD1
F4 X1
X2
U1
P27/-HLDA P2_7
P26/-HOLD P2_6
P25/-TC1 P2_5
P24/-DACK1 P2_4
P23/-DAQ1 P2_3
P22/-TC0 P2_2
P21/-DACK0 P2_1
P20/DAQ0 P2_0
P17/-READY P17
P16/-SCK0 P16
P15/T0
P14/INTR/POLL
P13/INTE2/-INTA
P12/INTE1
P11/INTE0 P11
NMI
P07/PHI OUT
P06 P05 P04 P03 P02 P01 P00
PT7 PT6 PT5 PT4 PT3 PT2 PT1 PT0
VTH
-RESET
-RFSH
-MREQ -MREQ
-EA/VPP
-IOSTB
-MSTB -MSTB
RD/-WR R/-W
27C512
A16 A15 A14 A13 A12 A11 A10 A09 A08 A07 A06 A05 A04 A03 A02 A01 A00
A16 A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0
07 06 05 04 03 02 01 00
DATA07 DATA06 DATA05 DATA04 DATA03 DATA02 DATA01 DATA00
U2
GND -OE/VPP
-PMSL3 -CE
43256
A16 A15 A14 A13 A12 A11 A10 A09 A08 A07 A06 A05 A04 A03 A02 A01 A00
A16 A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0
I/07 I/06 I/05 I/04 I/03 I/02 I/01 I/00
DATA07 DATA06 DATA05 DATA04 DATA03 DATA02 DATA01 DATA00
U3
-RMWE /WE
GND /CS
-RMOE /OE

FIG. 14

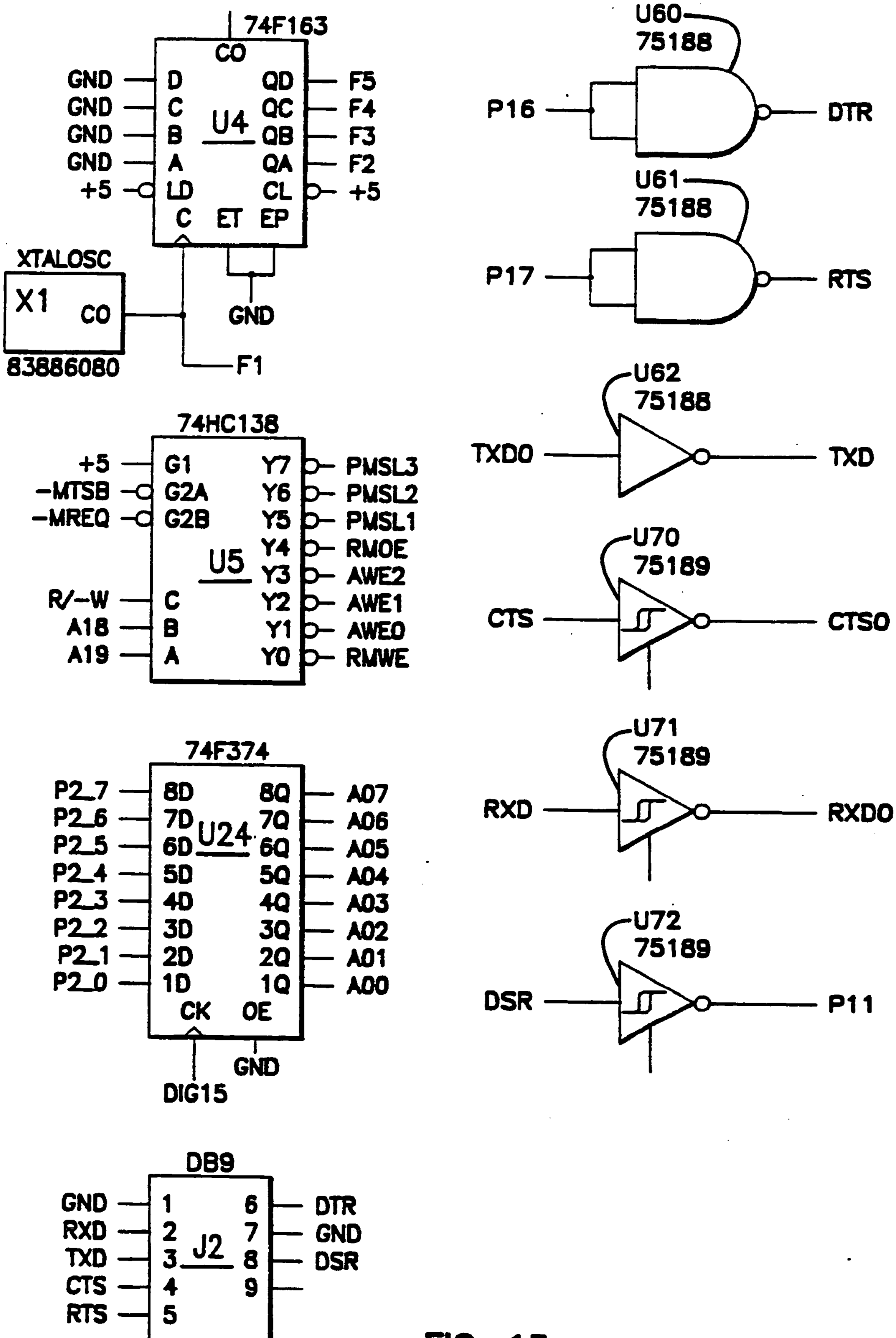

74F163
CO
GND D QD F5
GND C QC F4
GND B U4 QB F3
GND A QA F2
+5 LD CL +5
C ET EP
XTALOSC
X1 CO
83886080
GND
F1
74HC138
+5 G1 Y7 PMSL3
-MTSB G2A Y6 PMSL2
-MREQ G2B Y5 PMSL1
Y4 RMOE
U5 Y3 AWE2
R/-W C Y2 AWE1
A18 B Y1 AWE0
A19 A Y0 RMWE
74F374
P2_7 8D 8Q A07
P2_6 7D U24 7Q A06
P2_5 6D 6Q A05
P2_4 5D 5Q A04
P2_3 4D 4Q A03
P2_2 3D 3Q A02
P2_1 2D 2Q A01
P2_0 1D 1Q A00
CK OE
GND
DIG15
DB9
GND 1 6 DTR
RXD 2 7 GND
TXD 3 J2 8 DSR
CTS 4 9
RTS 5
U60
75188
P16
DTR
U61
75188
P17
RTS
U62
75188
TXD0
TXD
U70
75189
CTS
CTS0
U71
75189
RXD
RXD0
U72
75189
DSR
P11

FIG. 15

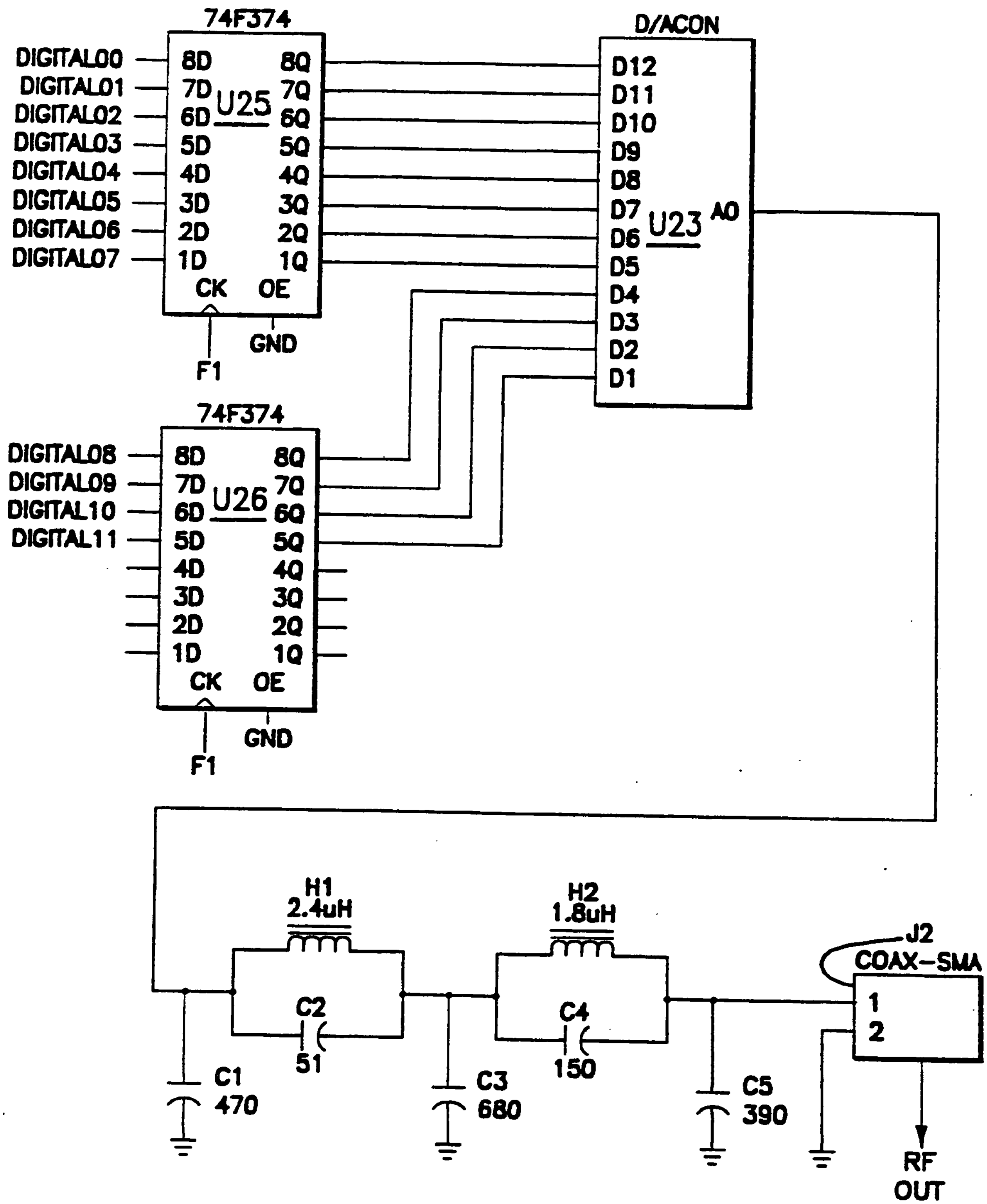

74F374
U25
DIGITAL00
DIGITAL01
DIGITAL02
DIGITAL03
DIGITAL04
DIGITAL05
DIGITAL06
DIGITAL07
8D 7D 6D 5D 4D 3D 2D 1D
8Q 7Q 6Q 5Q 4Q 3Q 2Q 1Q
CK OE
F1
GND
D/ACON
U23
D12 D11 D10 D9 D8 D7 D6 D5 D4 D3 D2 D1
A0
74F374
U26
DIGITAL08
DIGITAL09
DIGITAL10
DIGITAL11
8D 7D 6D 5D 4D 3D 2D 1D
8Q 7Q 6Q 5Q 4Q 3Q 2Q 1Q
CK OE
F1
GND
H1
2.4uH
H2
1.8uH
C2
51
C4
150
C1
470
C3
680
C5
390
J2
COAX-SMA
1
2
RF
OUT

FIG. 16

FIG. 17

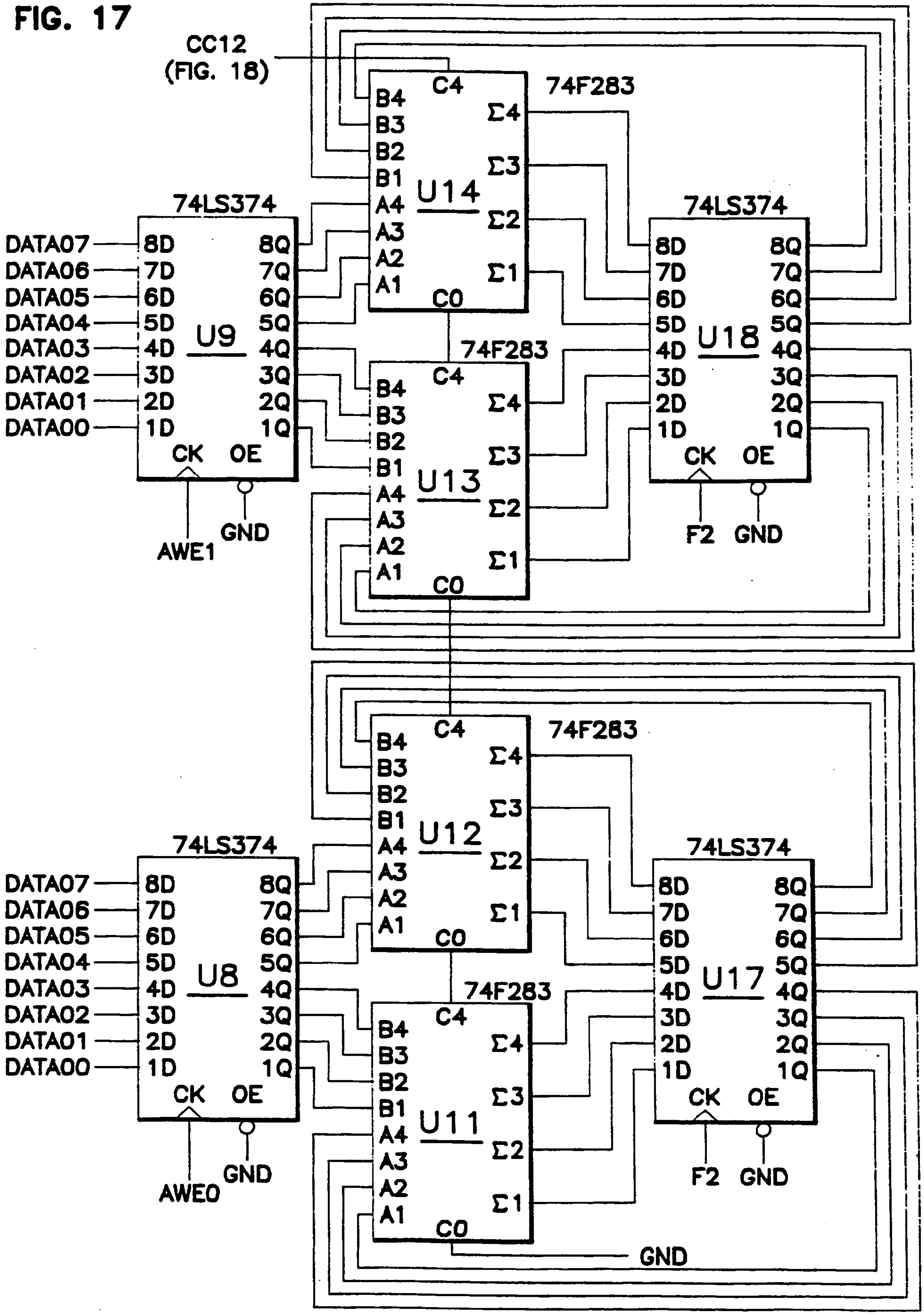

CC12
(FIG. 18)
74F283
74LS374
74LS374
DATA07
DATA06
DATA05
DATA04
DATA03
DATA02
DATA01
DATA00
U9
U14
U18
U13
74F283
AWE1
GND
F2
GND
74F283
74LS374
74LS374
U12
U8
U17
U11
74F283
AWE0
GND
F2
GND
GND

FIG. 18

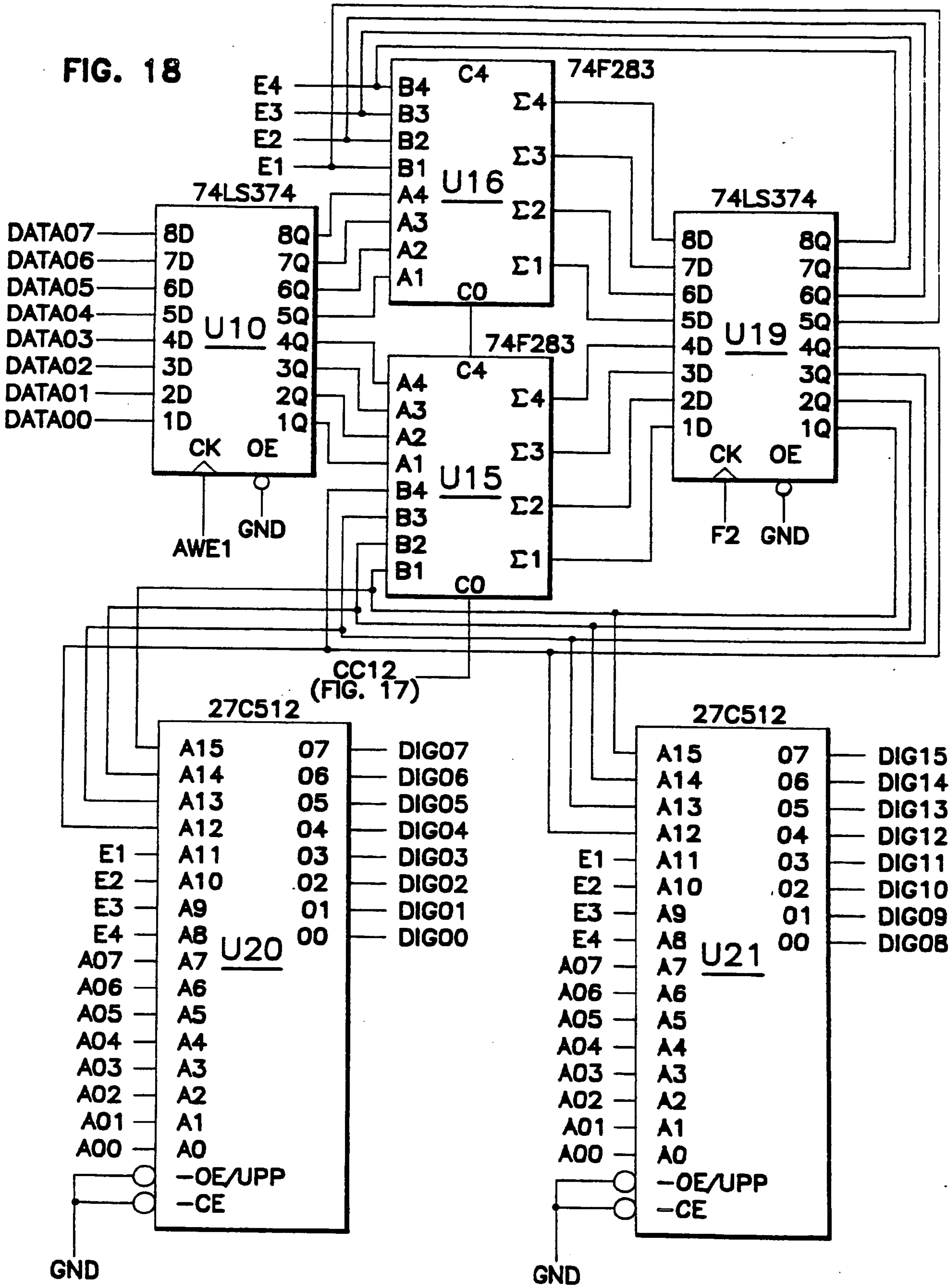

74F283
C4
B4
B3
B2
B1
A4
A3
A2
A1
U16
Σ4
Σ3
Σ2
Σ1
CO
E4
E3
E2
E1
74LS374
DATA07
DATA06
DATA05
DATA04
DATA03
DATA02
DATA01
DATA00
8D
7D
6D
5D
4D
3D
2D
1D
U10
8Q
7Q
6Q
5Q
4Q
3Q
2Q
1Q
CK
OE
AWE1
GND
74F283
C4
U15
74LS374
U19
F2
GND
CC12
(FIG. 17)
27C512
A15
A14
A13
A12
A11
A10
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0
−OE/UPP
−CE
U20
07
06
05
04
03
02
01
00
DIG07
DIG06
DIG05
DIG04
DIG03
DIG02
DIG01
DIG00
A07
A06
A05
A04
A03
A02
A01
A00
GND
27C512
U21
DIG15
DIG14
DIG13
DIG12
DIG11
DIG10
DIG09
DIG08

FIG. 19

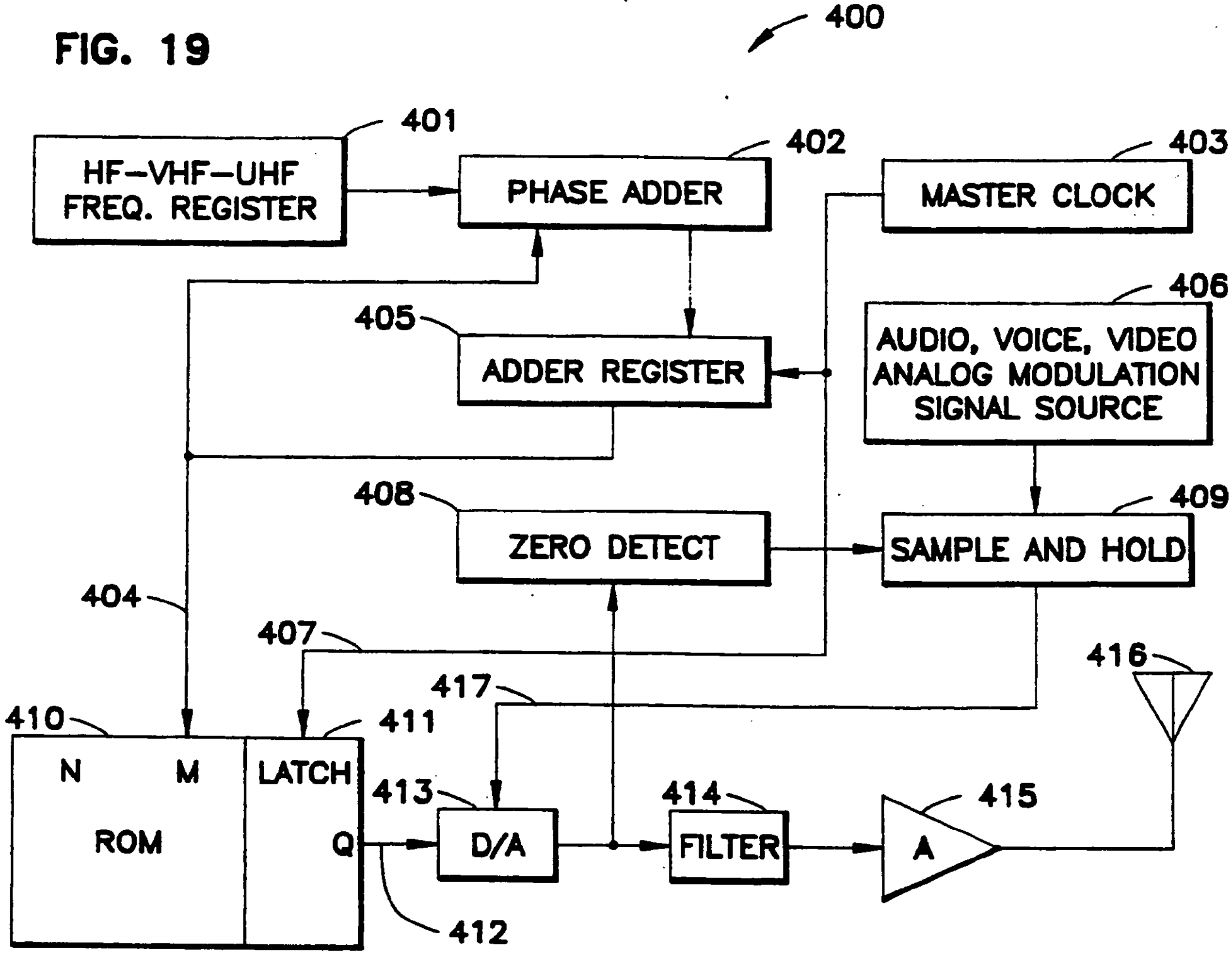

400
401
HF–VHF–UHF FREQ. REGISTER
402
PHASE ADDER
403
MASTER CLOCK
405
ADDER REGISTER
406
AUDIO, VOICE, VIDEO ANALOG MODULATION SIGNAL SOURCE
408
ZERO DETECT
409
SAMPLE AND HOLD
404
407
416
417
410
411
N
M
LATCH
ROM
Q
413
D/A
414
FILTER
415
A
412

FIG. 20

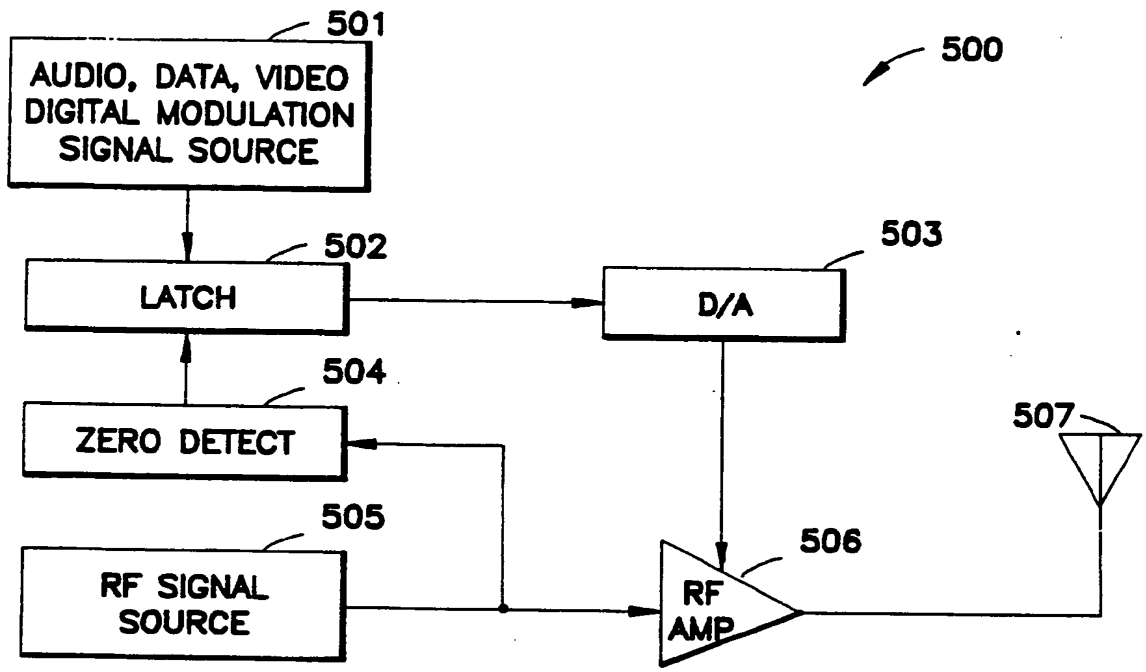

501
AUDIO, DATA, VIDEO DIGITAL MODULATION SIGNAL SOURCE
500
502
LATCH
503
D/A
504
ZERO DETECT
507
505
RF SIGNAL SOURCE
506
RF AMP

FIG. 21

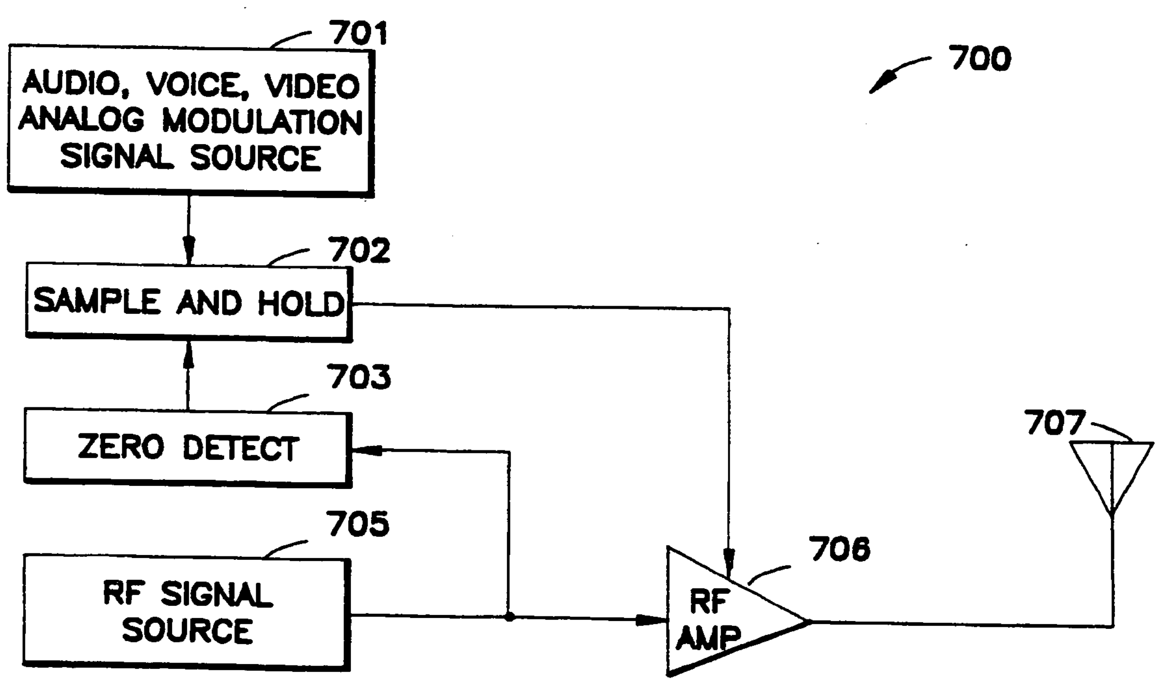

701
AUDIO, VOICE, VIDEO ANALOG MODULATION SIGNAL SOURCE
700
702
SAMPLE AND HOLD
703
ZERO DETECT
707
705
RF SIGNAL SOURCE
706
RF AMP

FIG. 22

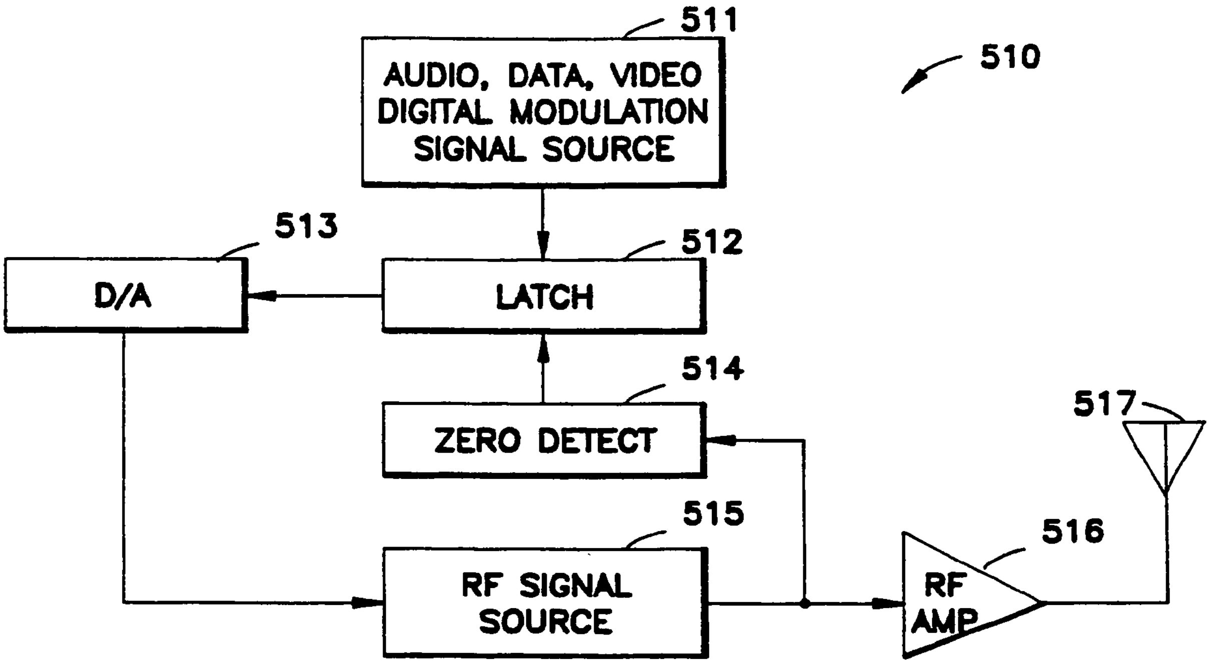
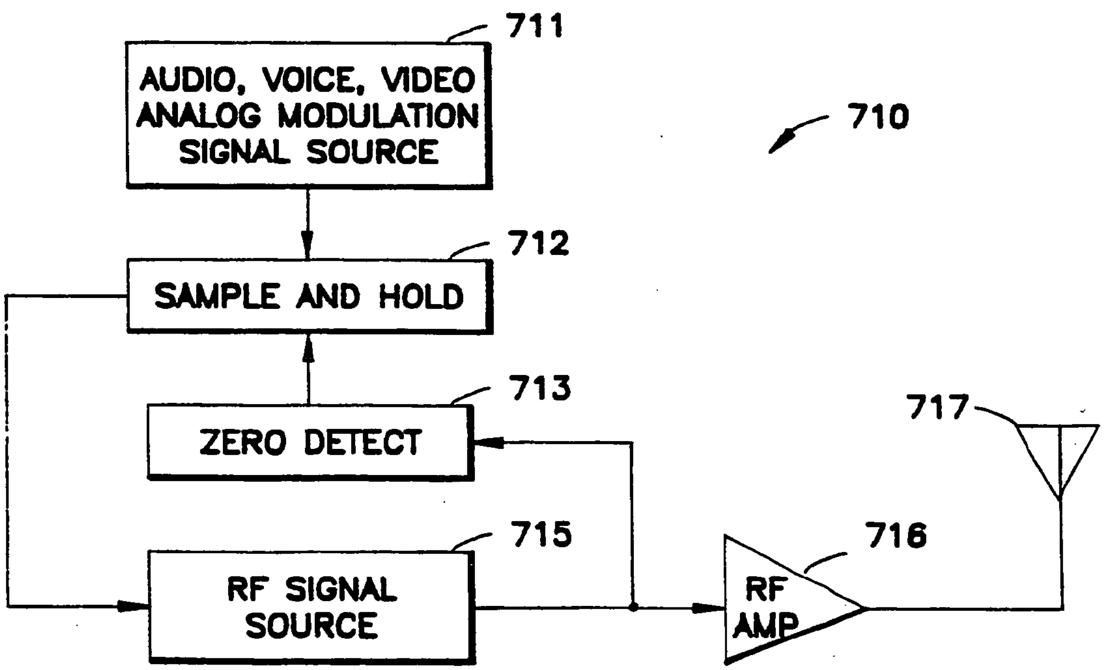

510
511
AUDIO, DATA, VIDEO DIGITAL MODULATION SIGNAL SOURCE
513
D/A
512
LATCH
514
ZERO DETECT
517
515
RF SIGNAL SOURCE
516
RF AMP

FIG. 23


711
AUDIO, VOICE, VIDEO ANALOG MODULATION SIGNAL SOURCE
710
712
SAMPLE AND HOLD
713
ZERO DETECT
717
715
RF SIGNAL SOURCE
716
RF AMP

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 90/05115

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H04L27/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	H04L ; H03C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	Hölzler and Holzwarth: "Theorie und Technik der Pulsmodulation" 1957, Springer Verlag, Berlin, DE see page 122, line 26 - page 27, line 21 --- -/--	1-84

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14 DECEMBER 1990	[illegible] JAN 1991
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	SCRIVEN P.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	US,A,3779321 (LANDWER ET AL.) 18 December 1973 see column 2, line 18 - column 3, line 28; figures 1, 2	1-6, 9, 11, 23-25, 28, 38 45, 46, 48, 49, 51, 54, 57, 65 66, 68, 69, 71, 74, 77
Y		12-15, 16, 19, 21, 22, 30-37 39, 40, 42-44, 56, 58-64, 76
A		7, 8, 10, 11, 17, 18, 20, 26, 27 29, 41, 47, 50, 52, 53, 55, 67 70, 72, 73, 75, 78-84

Y	HEWLETT-PACKARD JOURNAL. vol. 40, no. 1, February 1989, PALO ALTO US pages 52 - 57; F. H. Ives: "Multifunction Synthesizer for Building Complex Waveforms" see page 53, right-hand column, line 18 - page 54, left-hand column, line 9; figure 6	12-16, 19, 21, 22, 30-37, 39 40, 42-44, 56, 58-64, 76

	-/--	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	US,A,3919641 (KUROKAWA_ET AL.) 11 November 1975 see abstract; figures 1, 5	1-6, 9, 11, 23-25, 28
A		7, 8, 10, 12-22, 26, 27, 29-84

A	TELECOMMUNICATIONS AND RADIO ENGINEERING. vol. 21, no. 5, May 1967, WASHINGTON US pages 119 - 121; Terent'yev and Nuyanzin: "Amplitude Modulation by Varying the Coupling between Load and Oscillator" see the whole document	67, 70, 77-80

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/US90/05115

SA 40332

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 14/12/90
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-3779321	18-12-73	None	
US-A-3919641	11-11-75	JP-A- 50010906 GB-A- 1436918	04-02-75 26-05-76

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82